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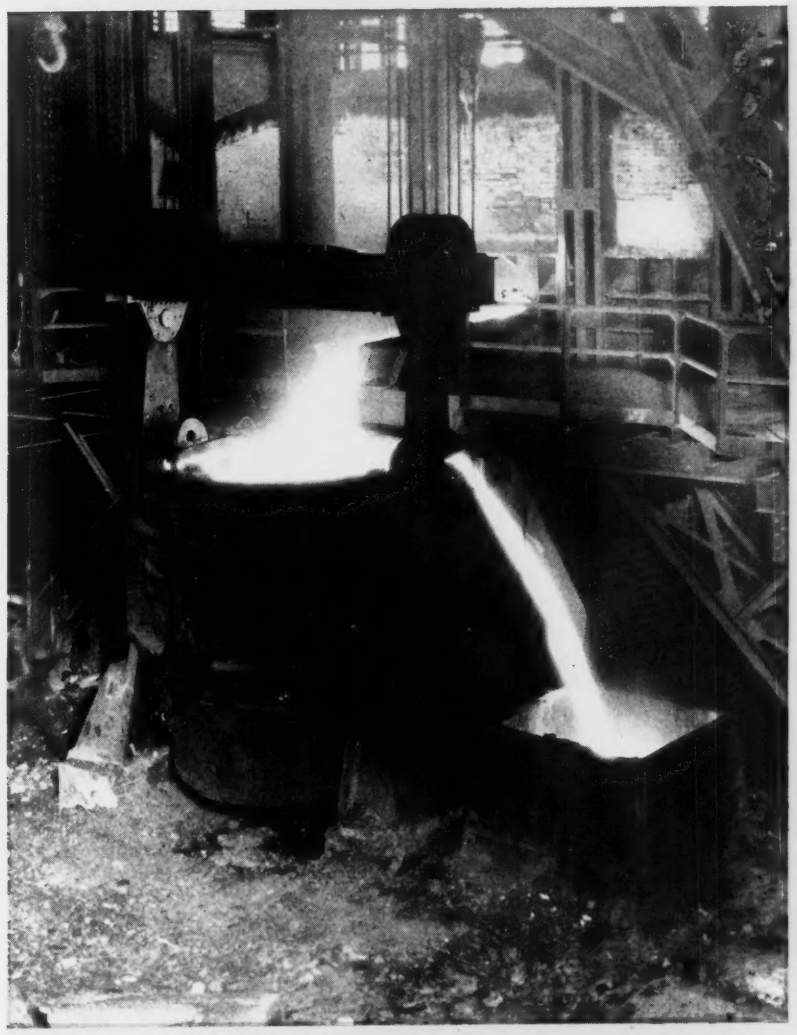

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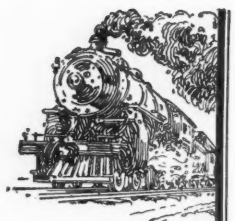
VOLUME XI, NO. 8
JANUARY, 1931

The Oil-Electric Locomotive Has None of the Expensive Habits of the Steam Locomotive



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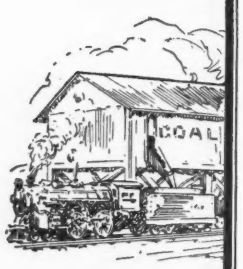

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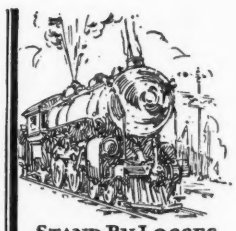
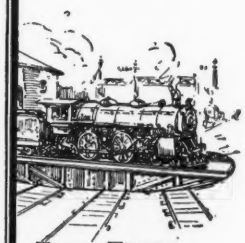


STAND BY LOSSES

TAKING WATER



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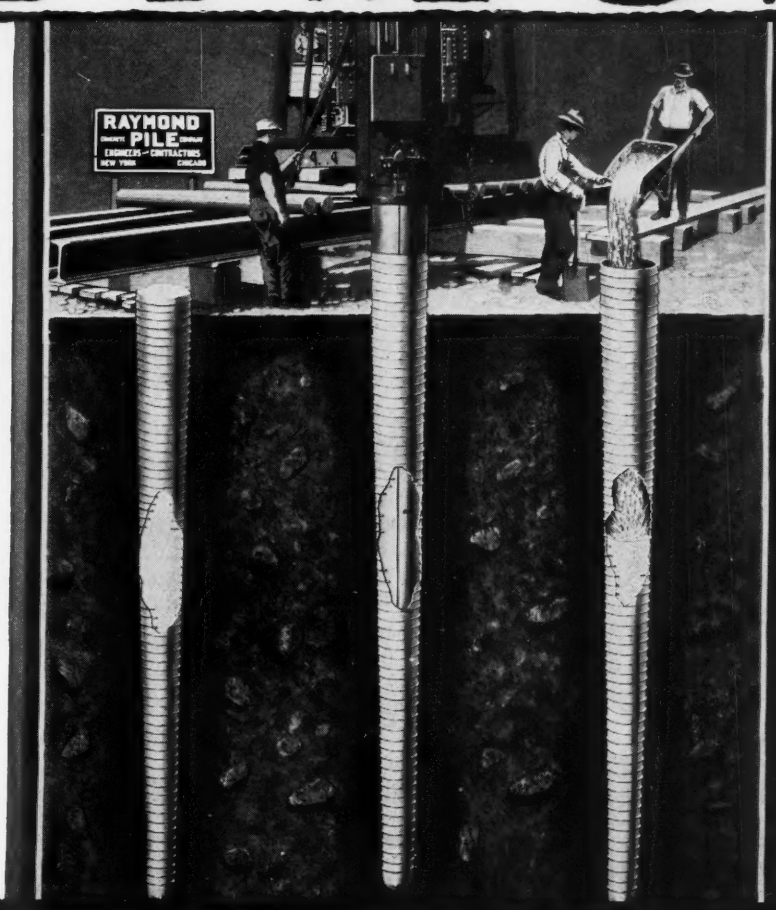

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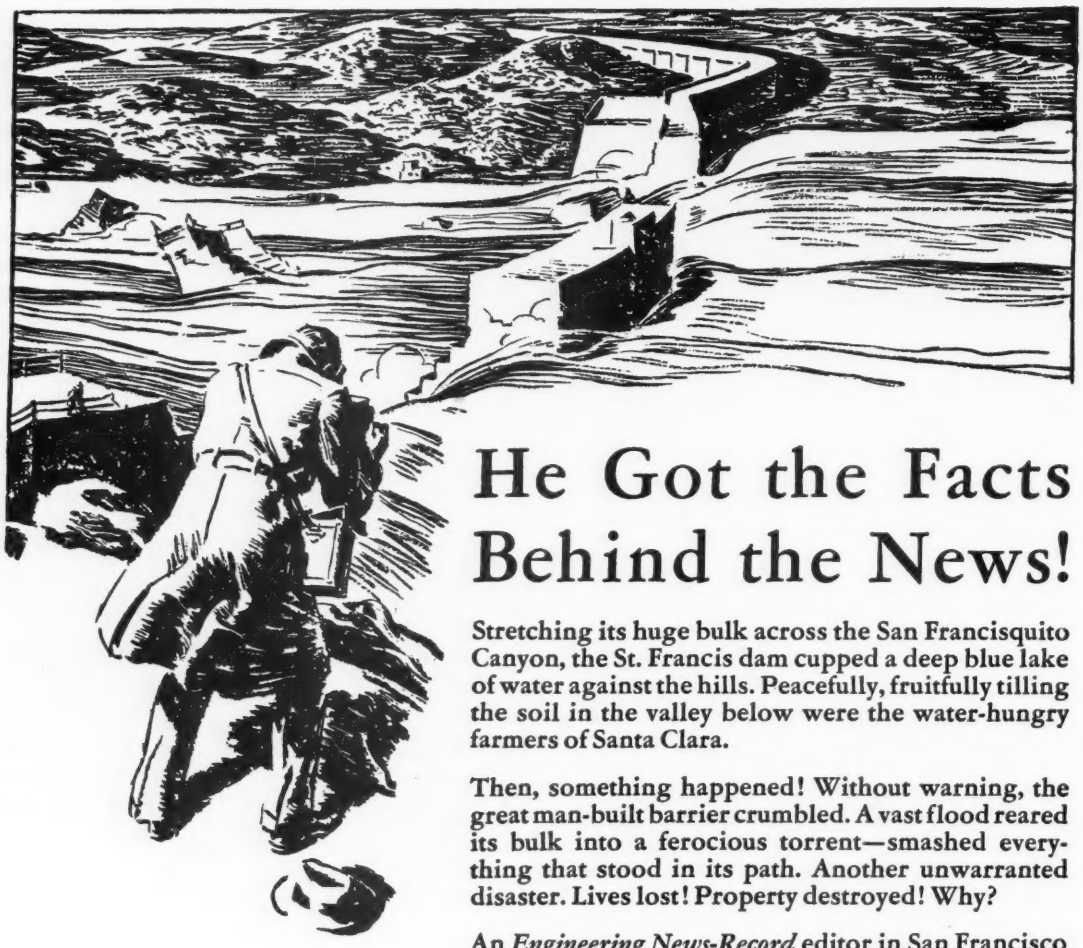

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Among Our Authors

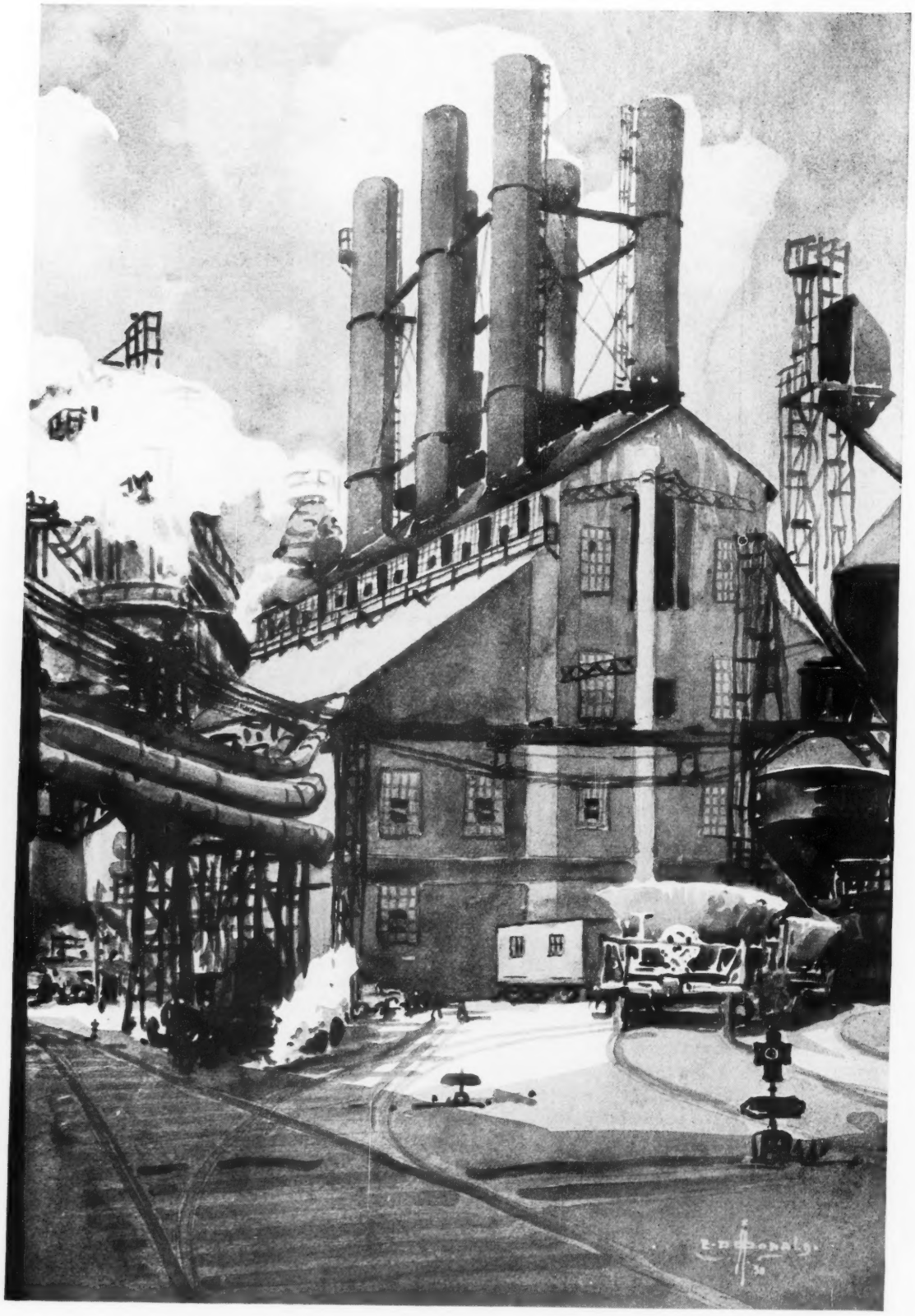
FELIX W. PAWLOWSKI, Guggenheim Professor of Aeronautics at the University of Michigan, has had training in Europe and America. His birthplace is near Warsaw, Poland, but he received his European education at schools in Saxony, Brunswick, and Paris, and also as designer and chief engineer of several machine industries. In 1914 he received his degree of Master of Science at Michigan, after coming to this country to work on motor car designs. He has been connected with the University since then, and has done much creative work in aeronautics. His past training fits him admirably to discuss some of the problems and solutions of overcoming the wind resistance of modern automobiles. This he does in "Automobile Aerodynamics."

MR. COLUMBUS ISELIN, author of "The New Oceanographic Institute," has been actively concerned with oceanography since his undergraduate days at Harvard when, as an amateur yachtsman, his interest was first attracted to this field. He has investigated the waters off the coast of Norway, has made cross sections of the Gulf Stream between the coast of this country and the Bermudas, and has contributed a method of taking samples of the ocean bottom which gives a core five feet long, rather than the fourteen inches previously possible. When the ship which is to be the Institute's floating laboratory arrives from Copenhagen this summer, Mr. Iselin will be her master. He is a navigator and sailor of no mean ability, who thinks nothing of taking a boat across the North Atlantic manned by a non-professional crew of college students. Last summer, on one such trip, he visited a fellow Oceanographer in Norway.

MR. JACOB DUNNELL, author of the article on Speedboats, is one of the leading engineers in this field in the country, having designed some of the most advanced and efficient speedboats yet built.

He was a student at both Princeton and M. I. T., being enrolled in the course in Naval Architecture and Marine Engineering here. Since leaving M. I. T. he has been associated with several boat companies and is now chief engineer for the Ludington Boat Corporation, designing raceboats as well as stock runabouts and cruisers. During 1928 and 1929 he spent considerable time testing out raceboat designs of his own, several of which proved extremely efficient as is indicated by the winning of the Albany, New York Marathon, the Outboard Races at Worcester, and one of the National Outboard Championships held at Boston.

He has been in an excellent position to test widely different types of boats and has kept as accurate figures as possible on all his test work, so that he has found several results probably not generally known, several of which are incorporated in his article.



Courtesy, Metal Progress

In the Blast Furnace Yard.

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XI JANUARY, 1931 NUMBER 8

Automobile Aerodynamics

BY FELIX W. PAWLOWSKI, F. R. A.E.S.

Guggenheim Professor of Aeronautics, University of Michigan.

THE question of wind resistance of motor driven vehicles is, in the final analysis, one of power economy and therefore reduction of cost of operation.

This question has become more important in recent years due to the development of some of the methods of transportation on land and the ensuing competition. The principal aspects of these economical reasons, for giving this question a new impetus, can be stated briefly as follows:

(1) The development of good (cement) roads has resulted in a demand for more speedy motor cars. This demand is being satisfied now, primarily, by the installation of more powerful engines in the cars. We have passed already the 100 H.P. mark but still have not reached the strived-for speed of 100 mi./hr.(a figure which exists in the minds of the public and the automotive engineers just as a round figure and in excess of the present railroad speeds). While gasoline is still rather cheap, this method of procedure might be satisfactory up to a certain limit.

(2) The development of faster automobiles, trucks and motor buses has detracted a considerable amount of freight and passenger business from the railroads, and in particular from the electric interurban lines. As a matter of fact many of the latter have been put out of business entirely during the past few years.

(3) There are rumors to the effect that some of the operators of steam railroads are beginning to worry about the development of aerial transportation as a possible competitor for a part of their business.

The power necessary to operate or to propel any of the above named vehicles depends primarily upon two factors: the air resistance and the road resistance.

In the present automobiles, operated on good cement roads, the air resistance begins to exceed the road resistance at about 40 mi./hr. and, since the road resistance is directly proportional to the speed of translation while the air resistance is proportional to the square of that speed, it is obvious that the problem of reduction of power necessary to propel these vehicles must be attacked first from the air resistance end.

Since the road resistance of railroad cars (steel wheels on steel rails) is several times smaller than the resistance of automobiles (rubber tires on cement road) per unit weight, then the air resistance in railroad cars begins to exceed the road resistance at smaller speeds than in the case of automobiles. Furthermore, since railroad cars can be operated *safely* at higher speeds than the automobiles (less traffic interference, no dodging of careless motorists, etc.), the question of reduction of air resistance for railroad cars is even of greater importance than that for automobiles.

There are, of course, other factors possible which may change the relative importance of road and air resistance: it suffices to mention here that since, at a given type of road, the road resistance or rolling friction is proportional to the weight of the vehicle, therefore this item in the total resistance to motion can be reduced, in the near future, due to the development of metallurgy which provides lighter and stronger structural materials for vehicles.

After these preliminary remarks we are going to consider the "wind" resistance of the automobile only.

The resistance to motion of a body in a resisting medium, at speeds below that of sound, can be stated in form of the simple equation

$$R = k s A v^2 \text{ or } = KAV^2$$

where R is the resistance or drag in lbs.;

k is the coefficient of resistance independent of the density of the medium, size of the body, and velocity of translatory motion;

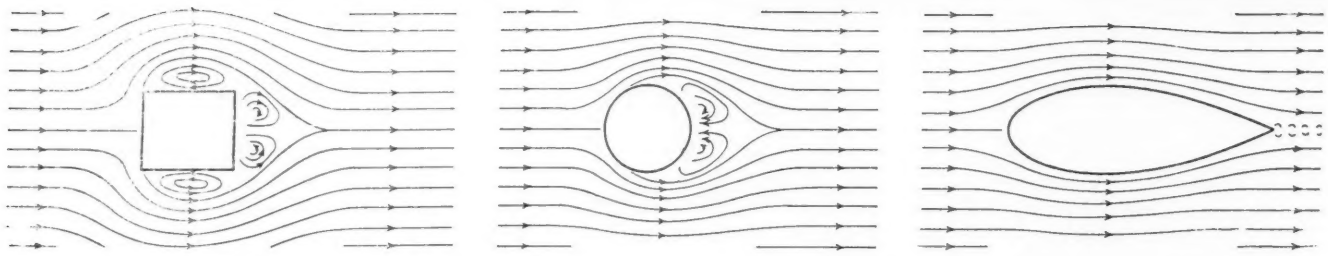
s is the density of medium, of air at standard sea level conditions (15° centigrade and 76 cm Hg column), and it is equal to .00237 slugs per cubic foot;

A is an area in square feet, characterizing the size of the body, and, therefore, it can be the square of any homologous dimension or a product of any two homologous dimensions of the geometrically similar bodies of different sizes. Most frequently, and very conveniently, for bulky bodies, as in the present case, it is the area of the body projected in the direction of motion or the maximum cross-section of the body in a plane perpendicular to the direction of motion.

v is the speed of motion in ft./sec., or

V the speed of motion in mi./hr.

K is the so-called engineering coefficient, giving the air resistance in lbs./sq. ft. of area, per mi./hr., therefore taking care of the standard air density and the conversion of mi./hr. into ft./sec., and thus saving one operation in the routine calculations, so that:



The cross sections of each of these objects is the same. The form of the body determines its coefficient of resistance. These are one, one seventh and one thirtieth respectively.

$$K = \left(\frac{528\upsilon}{3600}\right)^2 sk = .0051k$$

The above fundamental equation of aerodynamics ($R = KAV^2$), while very simple, is still rather crude, that is, incomplete and inaccurate, since it does not take into account the shape of the body and viscosity of the medium; it works very satisfactorily, however, if applied with discretion and within the proper limits.

We should keep in mind, also, the fact that in the case of motion of a body immersed in the medium the total resistance to motion can be subdivided into the following items:

(1) *Eddy-making resistance*, due to energy losses in stirring up eddies behind the body, particularly in bodies with blunt rear ends, or short bodies. This resistance is also referred to as *body resistance*, since it depends upon the shape of the body, and this part of the total resistance follows the law of square of the velocity.

(2) *Skin frictional resistance*, due to skin friction on the flanks of the body or portions of the body surface where the flow of air is parallel with the direction of motion or has a component parallel with the direction of motion.

(3) *Induced drag or resistance*, appearing only in cases where the body, due to its shape or attitude relative to the direction of motion, generates a cross-wind force and, therefore, a drag induced by this cross-wind force. This resistance is proportional to the square of the cross-wind force.

In smoothly shaped elongated bodies producing comparatively small eddies, the first item might be small and the second item might then be the major part of the total resistance. Since the skin friction does not follow the law of the square of the velocity of motion, namely, the exponent is not 2 but 1.83, therefore the *total drag*, to use the more familiar term, in smoothly shaped elongated bodies (streamlined bodies) will follow the law of the square of the velocity with varied degrees of inaccuracy.

Neglect of viscosity has the result that measurements of air resistance obtained from small scale-models of bodies tested in wind tunnels are not directly applicable to the prediction of performance of full size bodies. This is referred to in aerodynamics as scale effect, and the wind tunnel data must be corrected accordingly. The effect of viscosity of the medium can be explained crudely by the simple observation that "air is rather thick for a mosquito but is thin for an elephant."

To gain a clearer insight of the phenomenon of air resistance let us consider briefly the flow of air around various shapes. The resistance of a curved plate can be either greater or smaller than that of a flat plate normal to the direction of motion, depending upon whether the plate is concave or convex toward the relative air current and thus stirring up larger or smaller eddies respectively.

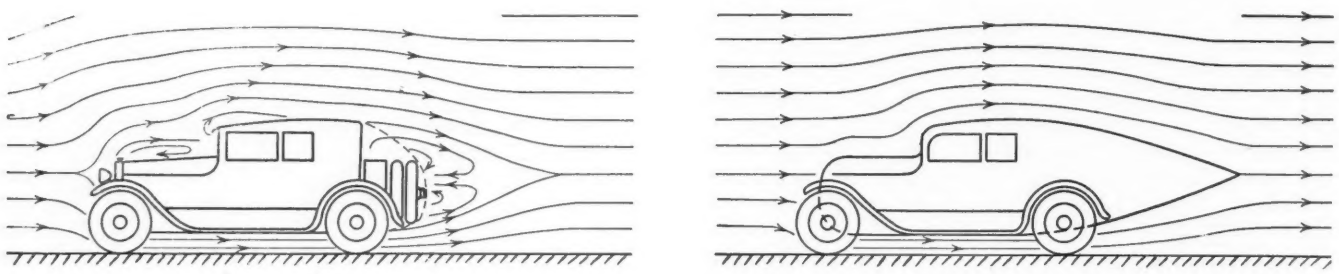
The parallelepiped in the left drawing has the same frontal area as the flat plate used in the above experiment, and the external outline of the eddies is the same in both. The rounded frontal part of the sphere in the middle drawing facilitates the flow of air around it and the coefficient of resistance to motion is approximately one-seventh that of a flat plate. The rounded front and the pointed rear portion of the streamlined body illustrated in the drawing at the right give a coefficient of resistance to motion that is approximately one-thirtieth of a flat plate.

This eddying flow is not stable, of course; the eddies will develop behind the body gradually, although swelling rapidly to full size, and then they will break loose allowing the formation of new eddies. We have, therefore, a periodic discharge of these eddies forming a train behind the body, which is referred to in aerodynamics as the Karman street of vortices.

Different methods of determination of air resistance of automobiles have been suggested and used by various investigators. These are: (1) dynamometric towing, (2) coasting down a hill of uniform grade, (3) mounting an automobile equipped with dynamometers for measuring the air resistance on a flat car that is pushed by a locomotive, (4) full-size wind-tunnel tests, and (5) scale-model wind-tunnel tests.

The first two methods present difficulties in accounting for the road resistance, friction losses in the wheel axles and the effect of ever-shifting wind, although the

(*Continued on page 312*)



The effect on eddy formation of streamlining the automobile body.

Multispeed Gear Transmissions

BY HERBERT CHASE

Associate Editor, American Machinist.

AUTOMOTIVE engineers agree that gearsets must be made quieter and shifting must be made easier, but other more radical changes are the subject of a great diversity of opinion, for they affect the type and size of engine to be employed, the rear axle gear ratio and the design of other units. Some engineers believe that the trend toward four-speed gearsets has been dictated more by a particular sales situation than by purely engineering consideration. The power-weight ratio of the complete car is an important factor in determining the type of gearset and the axle gear reduction employed. All four speed type gearsets in regular use on American cars today drive direct on first speed only, none are over-geared. Five makers aim to achieve quiet operation by the use of internal gear trains. One employs herringbone gears in constant mesh and one uses carefully ground and fitted spur gears. Easier shifting is attained by using dog clutches.

Quiet operation and easy shifting can be and are realized, however, to the same extent in some three-speed gearsets as in the four-speed variety. These qualities are not a peculiar advantage of the four-speed gearset.

Other advantages said to be realized by American four-speed gearsets now in use include: lower engine speeds with consequent decrease in engine noise and vibration, especially at high car speeds; fewer engine revolutions per mile with the resulting decrease in engine wear and friction losses; smaller reduction in rear axle gears, which consequently are smaller, lighter, cheaper, and quieter; lower propeller shaft speeds, resulting in less whip and less noise; improved fuel economy, resulting from a better power factor and lower oil consumption; ability to accelerate more rapidly without excessive gear noise in the next to top speed; shorter steps between gears and a lower low gear for emergency use; and general excellent traffic performance in third speed.

These advantages, however, involve a sacrifice in what is loosely termed "performance" in top speed. The car no longer has the same ability for rapid acceleration unless a shift to the quiet third speed is resorted to. If the driver is willing to make the shift, well and good, but it must be made as often as the car is accelerated if the rapid rate of acceleration to which American motors are accustomed is to be realized. Is the average driver willing to make this sacrifice? Apparently the answer has been given to the satisfaction of at least one car manufacturer, for, starting with small reduction axles when the four-speed gearset first was applied, this company soon went back to the larger reduction, but retained four speeds. Other companies continued to apply axle gears giving a large reduction and thereby sacrificed the chief advantages of four-speed sets.

Some engineers say in effect: "Get both the rapid acceleration and the advantages of a low-speed engine and small axle reduction without going to four-speed gearsets, by the simple expedient of using a larger engine to begin with." This has some obvious advantages in the way of simplicity, but in a large car group, it is presumed to involve the use of a heavier and larger engine and driving power and consequently a heavier and more expensive car. Ford and Chevrolet follow this practice and succeed in getting cars of light weight and low cost. All but seven other American cars have standard axle reduction of more than 3.85 to 1. Evidently, the disadvantage of more frequent gear-shifting rather than small axle reduction has led four-speed gearset advocates to sacrifice the chief advantages claimed.

THIS article is an abstract of a paper presented by the author before the Society of Automotive Engineers at their semi-annual meeting which was reported in the June, 1930, S.A.E. JOURNAL. *The abstract originally appeared in* THE AMERICAN MACHINIST. *We reprint it, with a few minor changes, because of recent developments in automotive engineering which are stressing the design of gearsets.*

The added complexity of the four-speed gearset, and in particular those using internal gears, is apparent. Some difficult and costly problems in manufacture and service also are involved, but similar problems arise also in some three-speed sets, in which quiet operation on other than direct speed is sought.

Internal gear types of gearset require three or four more roller bearings than the spur gear types and, in addition, substitute for some of the spur gears internal gears cut on flanged or sleeve members that are much more expensive to make than ordinary spur gears and seemingly more expensive than the herringbone type. Then, too, more extra parts, such as positive tooth clutches, are required than in spur gear types.

Most three-speed gearsets fall short on the score of quietness in second speed and to some extent in ease of shifting, but some steps to remedy this shortcoming have been taken in the design of one of our medium priced cars which uses herringbone gears for constant mesh and second speed trains.

Conventional gearsets on American passenger cars differ to some extent in details of construction, but the tendency has been toward compact designs, partly to limit weight and cost and partly to reduce the distance between the bearing centers, thereby making the shafts stiffer, decreasing deflection, and helping to reduce noise. Other items tending to reduce noise include the mounting of the gearcase on rubber supports and the use of rubber in the drive between gearset and axle.

Further decrease in noise might be realized also in mounting the gearset independently of the engine and using cushioning couplings between, by avoiding constant-mesh gearing, and by the use of some sort of insulating or noise-deadening material on the gearcase and its cover.

Helical gears apparently present possibilities in the way of decreased noise that should be investigated. Such gears can be shifted endwise in very much the same way as straight spur gears, if a small helix angle is used. With such an angle also, the end thrust is so

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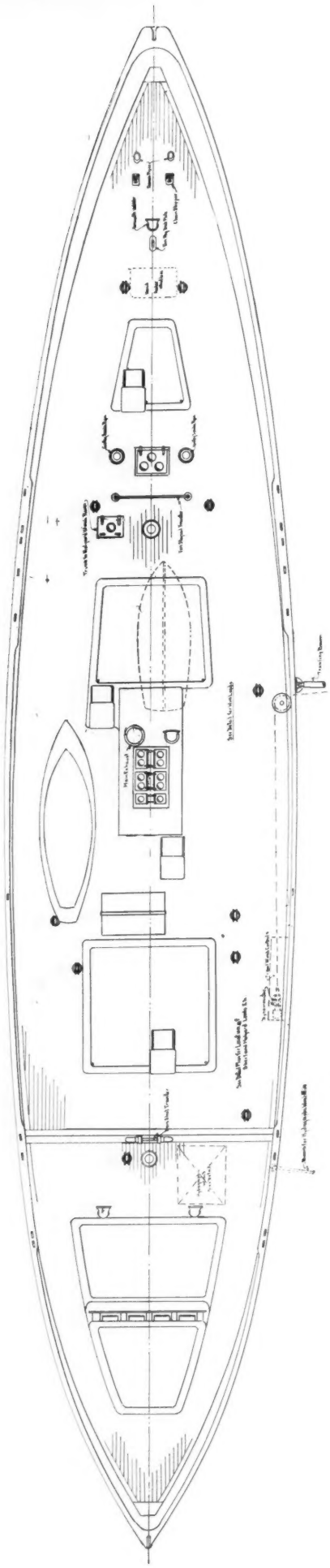
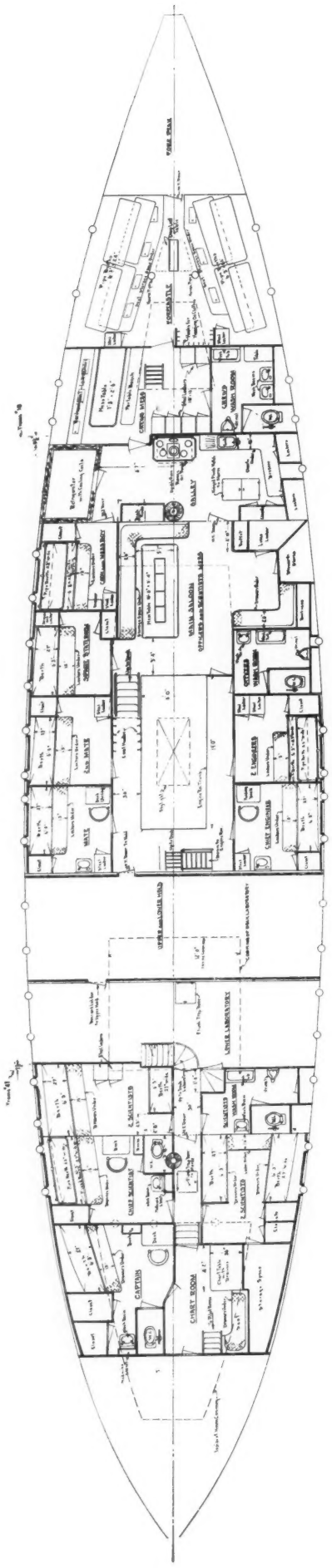
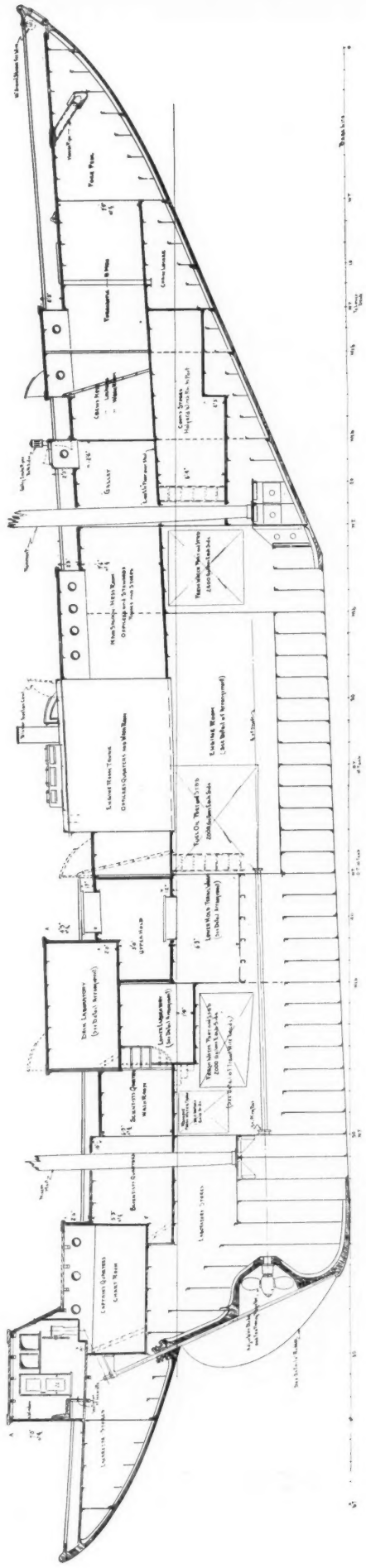






The New Oceanographic Institute

BY C. ISELIN

Assistant Curator of Oceanography, Museum of Comparative Zoology, Harvard University.

WITH the formation of the Woods Hole Oceanographic Institution, scientific students in this country who are interested in the many important problems of Oceanography will have, for the first time, adequate facilities for carrying out investigations in the ocean. Last February a grant of $2,500,000 from the Rockefeller Foundation set in motion the organization of an institution to build and operate a sea-going vessel and a suitable shore laboratory. The enterprise was extremely fortunate from the start, as Dr. Henry B. Bigelow accepted the position of director. Only under the guidance of a man thoroughly familiar with the many types of oceanographic problems could the institution hope to avoid the dangerous pitfall of disconnected and trivial research, and Dr. Bigelow is the very man to turn students' minds to the vital problems of the sea.

After some hesitation, Woods Hole on Cape Cod was selected for the location of the shore laboratory, partly because there already existed there, in the Marine Biological Laboratory, an exceptional oceanographic library, and partly because it offered a good harbor which was within easy reach of both cold and warm water. During the past summer a large laboratory was begun and a research vessel ordered. Since the latter is the most important piece of equipment for an institution of this kind, we will discuss some of the main problems which her designers had to face. In the first place, they were asked to design a vessel suitable for the safe navigating of all oceans at all times of the year, yet small enough to be worked by a total crew of fourteen men. Second, she had to be as steady as possible since laboratory work on a heavily rolling ship is nearly impossible, and thirdly, every effort must be made to facilitate the handling of heavy nets and instruments at sea.

Professor George Owen, of the Pratt School of Naval Architecture and Marine Engineering at the Massachusetts Institute of Technology, is responsible for the hull and rigging of this interesting ship, while his partner, Mr. Francis Minot, handled the problem of power and hoisting machinery. They have designed a jib-headed, ketch-rigged, steel vessel which is 142 feet in length and has a displacement of about 380 tons. She will use for auxiliary power a 300-horsepower, 2-cycle, 4-cylinder, crude-oil engine designed by a firm in Copenhagen. Her hull is of the schooner yacht type, but bulky and strong enough to stand any weather. She will carry a very moderate rig, having only about 7,200 square feet of canvas in her four working sails. The main hoisting winch, which will be placed in the lower hold, can handle 30,000 feet of one-half inch wire cable and the less powerful deck winch, the same length of much smaller wire. This vessel is now being completed in Denmark and will be ready for sea in the early spring.

THE plans on the opposite page are those of the first ship ever designed and built solely for oceanographic research. She is now on the ways in Copenhagen, for it was found that the cost of construction in Denmark was about two thirds of the cost in this country. Notice the scientists' quarters, laboratories, and gear not ordinarily found on shipboard.

The boat, an auxiliary ketch, was designed to be as steady as possible under all conditions to facilitate the laboratory work. Sailing ships are much more suited to this purpose than power vessels.

The reader may wonder what use is to be made of such expensive equipment and what type of problems await investigation in the ocean. The fact is that oceanography is a most important but little studied branch of science, and that geologists and meteorologists as well as biologists eagerly are waiting for the data which can be collected at sea by this new institution. It will be more interesting to consider here several particular lines of investigation rather than to discuss the general scope of oceanography.

From the point of view of Meteorology, the oceans present a great problem, because, although covering much of the earth, it is impossible to conduct accurate atmospheric investigations except from an especially equipped ship. Much of the extra-tropical weather is formed over the oceans and is strongly influenced by ocean currents. Moreover, there is a striking similarity between the atmospheric and oceanic circulatory systems. In both cases the density is primarily under the control of the temperature, while in the ocean the salinity, and in the air, the water vapor exert a retarding influence to the circulation. In both fields, the effect of the earth's rotation is an all important matter and in each the effect of the other is strongly marked. In short, the Woods Hole Oceanographic Institution will offer facilities for meteorologists to pursue their investigations out over the ocean, while the study of the fluctuations in ocean currents may furnish valuable data for long range weather forecasting.

The Geology of the ocean basins is also an important field which has hardly been attacked. Have the oceans always been as deep as they are at present or have continental land masses such as mythical Atlantis existed in former times where now there is deep water? What are the processes which have formed the continental shelves, and exactly how and where are sediments now being layed down at sea which are the same as some of the sedimentary rocks? These and other questions can only be settled by a study of the mud at the bottom of the ocean. Only a beginning has been made in this work, but the little which has been done has pointed to the possibility of important results. Since the character of oceanic deposits varies with the depth at which they

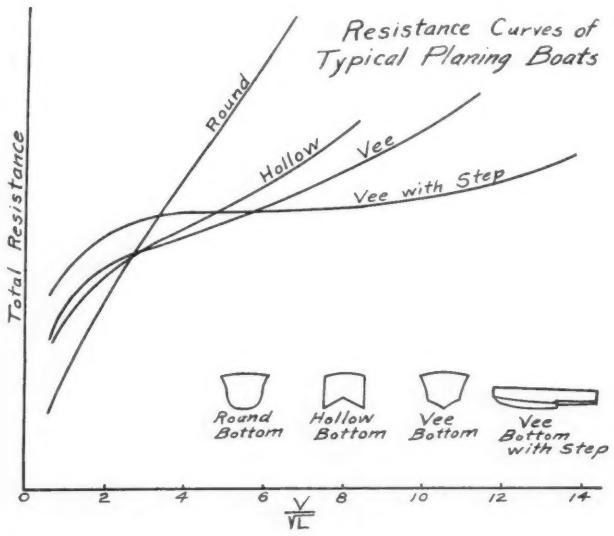
(*Continued on page 320*)

Speed Boat Design

BY JACOB DUNNELL

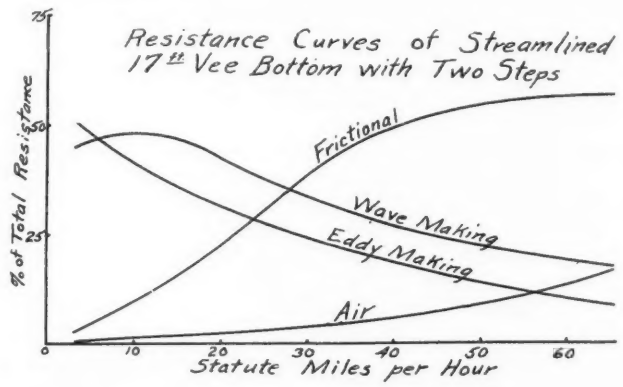
Chief Engineer, Ludington Boat Corp.

THE modern high-speed boat as compared with other means of transportation, is probably the least scientifically designed of any in use at the present time. By this I mean that any new design is either the result of a process of trial and error or merely a slight change from an existing design rather than one which is accurately figured out beforehand. For this reason the methods used by the numerous designers vary greatly and consequently the boats themselves are widely different, with the result that an article



written by any one designer must be limited almost entirely to his personal experience and will therefore embody few but his own ideas. There are no text books or standard works of reference from which any great amount of data can be gathered, so I shall try in this article to set forth the most important points in a fairly large series of experiments which have been performed with as many types of boats as were available. These experiments are necessarily limited in number because they must be performed with full-sized boats, as there is at present no model testing tank suitable for this type of high-speed work.

At the present time there are three distinct types of boats in general use. The round or convex bottom, the hollow or concave, and the vee bottom. Each of these have several sub-types such as the single or multiple transverse step, the longitudinal step, etc., and there are, of course, a great many variations of each of these. In this article I will deal only with the most typical of each major type. The round bottom is the old conventional type which has always been used in all kinds of boats and is merely changed so as to be efficient at high speeds. Due to the fact that there is no sharp angle in the surface of the hull where the sides meet the bottom, it is very difficult to reduce the wetted surface at high speeds because the water tends to follow up the sides. The hollow bottom has not been greatly used. It has, however, several features which are a distinct advantage in some particular types of work. Due to its hollow shape it traps all the spray underneath it and makes a very clean running boat, but this very fact makes it exceedingly hard riding in any kind of rough water. It carries a heavier load at fairly high speed than the other types; but, due to the excessive pounding caused by the hollow shape of the bottom, many structural difficulties are encountered in giving it the proper strength. The vee bottom is the most generally used and is the only one which is really efficient at extremely high speeds. With one or more transverse steps it is the fastest type of boat known and is almost exclusively used for racing. The accompanying curves of resistance show clearly at approximately what speeds these different types of bottoms give the best performance. These curves show the total resistance plotted against the speed-length ratio, which is the speed in knots divided by the square root of the load water line length. This is the only possible means of comparison, as a long boat will show proportionately less resistance at a given speed than a short one. It is, however, not entirely satisfactory for planing boats as their water line at speed is far shorter than the load water line at rest. However, this water line at high speed is constantly varying due to the motion of the boat and is almost impossible to determine so that the water line at rest is used throughout for comparison. It will be seen from these curves that the round bottom boat is more efficient at low speed-length ratios and that it is almost impossible to install enough power to drive it at high speed. In the medium speed range, although not quite as efficient, it is very good because it has no sharp change in performance when planing occurs. The hollow bottom is about half way between the round and the vee and has no particular advantage as far as its resistance is concerned. The vee bottom without a step is the best after full planing, which occurs at a speed-length ratio of about three, and continues to show a very good performance up to a speed-length ratio of about eight which is approxi-



mately the limit for general use. Below the planing speed its performance is very sluggish and the resistance is very high. The vee bottom with one or more steps is by far the most efficient for extremely high speeds and particularly for racing, but it will not carry any great load and its resistance is very high at low speeds. It is interesting to note at this point that modern design does not seem to be able to get above a speed-length ratio of fourteen. The fastest speed which has ever been made

is about 98 m.p.h. in a 38′ boat with about 2200 H.P. which gives a speed-length ratio of 13.7. In a smaller class, limited to boats 17′ long and motors of about 151 cubic inch piston displacement, which develop about 175 H.P. a speed of about 65 m.p.h. has been obtained. This gives a speed-length ratio of 13.75. Again, in the small outboard motor classes, a 9′ boat with a 30 H.P. motor has made a speed of 49 m.p.h., giving a speed-length ratio of 13.65. These three are typical cases of very efficiently designed boats of entirely different size and power, yet all have a single step bottom and have almost identical speed-length ratios.

The total resistance of any boat is made up of four factors: Frictional resistance, wave making resistance, air resistance and eddy-making resistance. The frictional resistance is the actual skin friction of the bottom of the boat passing through the water and may be computed from the expression $R = fsv^n$ where f is the coefficient of friction which usually equals about .013, s is the area of the wetted surface in square feet, v is the speed in knots, and n is an exponent varying from 1.83 to 2.0, the latter being fairly accurate for short planes. The value will vary greatly according to the material and finish of the bottom, and of course according to the area of the wetted surface. The most efficient finish for extreme speeds seems to be a coat of graphite which, in various forms, is usually applied to racing boats before each race. For ordinary service a smooth paint or varnish surface is very satisfactory. This frictional resistance is the most important factor at high speeds, and it is for this reason that various forms of steps are used in the bottom of boats in an effort to cut down the area of the wetted surface and consequently the skin friction. The wetted surface may be cut down to a surprisingly small amount at high speeds; but if it is cut too far the angle of attack of the bottom will become so great that the decrease in wetted surface is more than offset by increased wave-making resistance. The wave-making resistance is the work done by the boat in displacing the water as it moves through it, causing four separate series of waves, i.e., a preceding and a following transverse series, and a bow and stern diverging series. All four of these are very apparent in large slow boats, but in boats designed for high speed the stern transverse series is by far the most important at low speeds while the bow diverging series is the most important at high speeds. The wave-making resistance is a very large factor at low speeds but becomes less and less as the speed increases, due to the fact that the boat is planing on top of the water and displacing very little. The air resistance in the average type of boat is approximately $.004AV^2$ where A is the maximum cross sectional area of the boat above water in square feet and V is the speed in knots. Proper streamlining will reduce this by almost 50% and is an important factor. It must be remembered, however, that in very high-speed boats, with one or more steps, another form of air resistance will be introduced approximately equal to the above reduction. This is due to the tremendous amount of air sucked in under the steps which cannot be streamlined in any way without interfering with the shape of the bottom. Eddy-making resistance includes all the disturbances due to projections below the bottom of the boat and sharp angles in the hull itself. All of these under water parts may be efficiently streamlined with the exception of the propeller shaft which, of course, not only has to be round but is rotating at high speed thus increasing the resistance. Eddy making is a very important factor at low speeds, particularly in boats with steps where there is a lot of turbulence behind the steps until the boat begins to plane. At high speed, with everything properly streamlined, eddy making is not a very important factor.

The champion of the International 5½ liter class. At high speeds air streamlining is becoming an important factor.

(*Continued on page 310*)

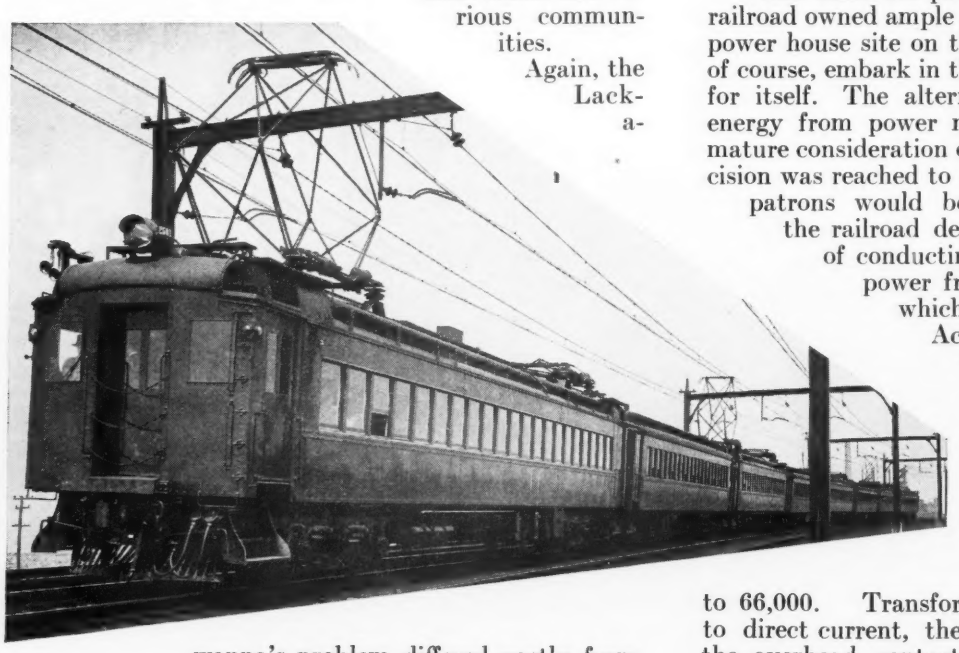
D. C. Railway Electrification

BY T. T. MAXEY

Special Representative, Delaware, Lackawanna, and Western R. R. Co.

CHANGING the motive power from steam to electricity on a railroad of long standing which traverses a highly developed and thickly settled territory involves, as an engineer knows, no end of serious and ticklish problems of which, of course, the man in the street obviously has little or no conception.

Not the least of such undertakings, and yet a prime necessity, is a complete and thorough survey of all existing wires, cables, conduits, water and gas mains, sewers and what not — anything and everything which might cause any sort of unscheduled interference or absorb energy from the transmission or contact wiring systems and create unexpected, harmful and unnecessary disturbance — either on the spot or at some remote point. As might be expected, a host of re-adjustments had to be thrashed out between the railroad, numerous individuals and various communities.



Again, the Lackawanna's problem differed vastly from all important existing suburban electrification projects. Instead of closely following water courses or operating over relatively level ground, the Lackawanna, after crossing the meadows between Hoboken and Newark, takes to the undulating hills of Northern New Jersey. This situation naturally injects both grades and curves into the picture and this, in turn, involved energy consumption tests, weights and speeds of trains, efficient and convenient spacing and location of substations, the conductivity of the contact system under different arrangements and a long line of related problems. The research work on this job was noteworthy for its thoroughness. Nothing which promised to make the finished installation more surely or safely suited to the present or probably future needs of the patrons of the railroad was knowingly overlooked.

The entire terminal zone and the train-run terminals both had to be re-arranged and re-built. All round houses, ash pits, coal chutes, water tanks and other steam service structures gave way to buildings suited for the servicing and maintenance of electrified equipment. What is more, all of these necessary transitions had to take place while the railroad was under operation and with the minimum of delays to traffic.

After thoroughly considering the present and estimating the probable future demands on the system, the Committee on Electrification decided upon the use of 3,000-volt direct current, in the belief that it was best suited for a dual service — the present suburban and future long distance train operation. This is the first adoption of 3,000-volt direct current for motor car service in America and the first in the world to utilize this voltage in a large suburban installation.

It was determined to carry the power lines by overhead means instead of by third-rail system, because this would conserve power—it being regarded as impossible to transmit such high voltage by third-rail without serious power leakage and endangering the public safety.

Next came the problem of power production. The railroad owned ample and suitably located ground for a power house site on the Hackensack River and could, of course, embark in the power manufacturing business for itself. The alternative was to purchase electric energy from power manufacturing companies. After mature consideration of the pros and cons involved, decision was reached to the effect that the interests of the patrons would be served to better advantage if the railroad devoted its energies to the business of conducting transportation and purchased power from the public service companies which served Northern New Jersey. Accordingly, long term contracts were made with three existing companies conveniently located for the necessary power

Five substations, located at strategic points, were constructed by the railroad for the reception of alternating current to be delivered at voltages varying from 13,200 to 66,000. Transformed to 3,000 volts, and rectified to direct current, the electricity then flows through the overhead contact system for distribution to the trains as the service requires.

Mercury arc rectifiers are used exclusively for supplying current to the overhead distribution system for train operation. This type of converting unit was chosen by reason of its efficiency—97% a-c. to d-c. at full load. Three sizes of rectifiers are used—3,000, 2,000, and 1,500 kw. — the latter for the sake of flexibility and grouped in pairs to form 3,000 kw. units.

This is the first major electrification project in the United States to employ rectifiers exclusively for supplying d-c. power. It is the first time that 3,000-volt rectifiers have been used in this country and the 3,000 kw. units are the largest rectifiers operating at this voltage in the world. A total of 37,000 kw. in rectifiers are installed in the five substations. A spare 3,000 kw. unit is also available for use at either of the two major stations, making a total of 40,000 kw. available for the electrification.

The largest transformer is about 17 feet high and 12 feet in diameter. Core, coils and casing contain about 45,000 pounds of steel and copper and house about 3,700 pounds of oil for insulations and cooling purposes.

The stations are located at six points in the elec-

trified zone. This arrangement promotes the maximum utilization of the distribution copper and also affords a ready means for sectionalizing faults.

High-speed air circuit breakers are used for both sub and tie stations for all direct current switching and provide ample protection for both conversion and motor car equipment.

Four million, seven hundred and seventy-three thousand feet of wire and cable weighing 1610 tons were ordered for the job. Of this, 700,000 feet, weighing 525 tons, were messenger cable, made up of a high-tension core of seven bronze wires surrounded by 13 copper wires; 300,000 feet, weighing 65 tons, bronze messenger wire for use in yards and on sidings; 1,700,000 feet, weighing 550 tons, bronze contact wire for supplying power to trains; 2,050,000 feet, weighing 400 tons, bare, stranded copper cable of varying sizes, for use on auxiliary feeders, signal and miscellaneous power circuits; 23,000 feet, weighing 70 tons, underground cable, 2¼ inches in diameter, for use in carrying power transmission lines wherever necessary.

Eight million pounds or 4,000 tons of steel were ordered to carry this wiring system. There are 860 overhead supports and 249 pull-off and dead-end poles. The feet of these supporting columns are embedded in concrete bases of the so-called "box" type, set at depths which vary according to character of soil and slope of bank, the average being about five or six feet. The top dimensions of these footings approximate 2′3″ by 2′9″ and spread to an average—the exact size varies, of course, according to the width and weight of the cross span to be supported — to 5 by 7 feet at the bottom — the long way corresponding with the up-and-down direction of the track.

Surprisingly few of the supporting columns are duplicates. Each was formed specially, to fit the conditions which existed at the particular point of erection. These columns are of the H-type, with simple knee braces, while the cross members over three tracks or less (unless, owing to some unusual local condition a special strain is involved) are usually of simple-truss type and of the lattice-truss type when placed over more than three tracks. The cross member covering a three-track span weighs 49 pounds to the foot.

Multiple-unit train service is used — a motor car and a trailer, semi-permanently connected, constituting a unit. These units, in turn, are coupled together to make trains of from four to twelve cars. The motor cars are 70 feet 3½ inches long over bumpers, seat 84 passengers and weigh 147,200 pounds. The trailers are 70 feet long, seat 78 and 82 passengers and weigh 106,400 pounds. One toilet is provided in each unit. One hundred and forty-one units (282 cars) have been provided, of which six are club cars, fifteen combination baggage and passenger cars, and two combination mail and passenger cars.

Incorporated in these cars are a number of innovations — 1,500/3,000-volt motors for multiple-unit cars, motor ventilating air inlets in the roofs, 3,000-volt heater circuits and pantographs equipped with self-aligning roller bearings, to mention a few of the outstanding features.

The cars are of all-steel construction, with the exception of the aluminum doors, inside finish and roof sheets on the motor cars. All car vestibules are provided with trap doors and equipped with electro-pneumatic brakes. All but five of the motor cars are equipped with roller bearings.

Each motor car is equipped with four 235 H.P. motors which provide a total of 940 H.P. per motor car unit. This represents an aggregate of 5,640 horsepower, for a 12-car train, with seating space for approximately 1,000 passengers, which is greater than the largest steam locomotive ever constructed. In fact, these motors deliver a higher output per pound within a given space limitation than has been secured with any other motor of its type and voltage. These cars can be operated at high maximum speeds. By reason of the even distribution of the total power throughout the train, very high rates of acceleration are obtainable. Coupled with the high maximum speeds this operates to produce material reductions in the schedules which existed under steam operation. Acceleration is automatic. This makes the trains unjerkable, which, of course, promotes riding comfort. When power is fed to the motors the speed of the train is automatically accelerated at the rate of 1½ miles per hour, per second, on level track. This is about four times as fast as steam trains gather speed. If an engineer should be taken suddenly ill and remove his hand from the control lever while his train was in motion, "dead man" operation would become effective instantly and automatically the train would be quickly brought to a smooth stop.

These cars are electrically heated, with thermostatic control, direct from the 3,000-volt trolley, and are lighted by standard 32-volt incandescent lamps enclosed in artistic bowls.

The interior of the new cars have been done in unusually light and harmonious colors which create an airy and inviting atmosphere. The ceilings are cream, the upper side walls a light buff; the seats are light yellow rattan — clean, sanitary (dirt slides off), with green metal frames and mahogany side arms; the lower side walls are also dark green, while the floors are battleship gray.

The whistle and bell of former days have given way to a four-toned pneuphonic horn as a warning signal. More pleasing of tone and equally penetrating, these horns deflect sound both fore and aft and protect the public when the train is backing up as well as when moving forward. Incidentally, they make living near the right of way more comfortable in the well-populated region which is penetrated by this electrification.

The commutation zone along the Lackawanna — happy admixture of wooded mountains, charming valleys and lovely little lakes that it is — often referred to as the Jersey Alps because of its rare landscape and proximity to both New York and Newark, was destined to become the home of great numbers of the best people in the land. As a natural consequence, the commuter traffic handled by the Lackawanna is one of the heaviest around New York and long since made necessary a 17-track, 6-ferry-slip terminal, for its exclusive use at Hoboken — directly opposite Mid-Manhattan — where the Lackawanna reaches the Port of New York. During peak hours, rushing commuters stream through this convenient terminal — to and from which both broad, double-decked ferries and under-river tube trains ply constantly both day and night — at the rate of 300 each minute. Supplied with faster, more comfortable and more frequent train service, this Lackawanna served sector of North Jersey steps into the limelight as about the ultimate in suburban regions in this nation.

There is an interesting adjunct, as it were, to this project. On the west bank of the Hudson River, adjoining the Hoboken Passenger Terminal on the south, are the extensive freight handling and warehouse developments of the Lackawanna, steamship piers, etc. Some five miles northwest is Secaucus (New York Transfer), to which less-than-carload freight origina-

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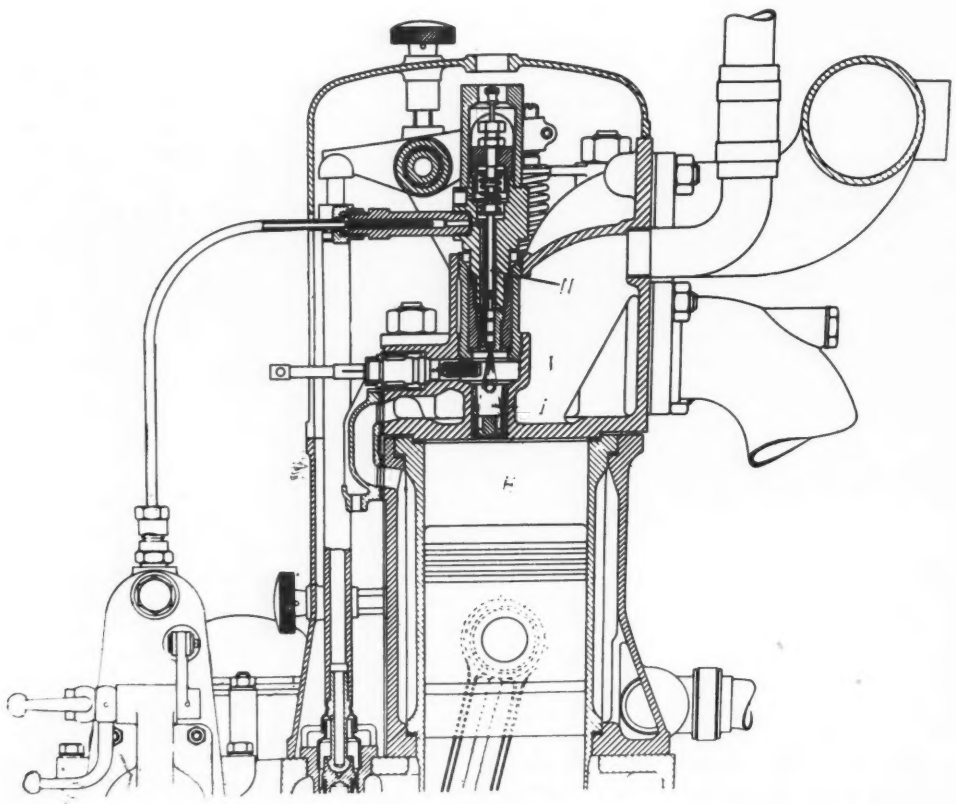
Diesels for Automotive Power

THE Diesel internal combustion engine, already well known in the marine world as an economical and dependable power plant, is now coming into use as an automobile engine. The low cost of operation and the reliability of the Diesel, as compared with the gasoline engine, have long been recognized, but until recently its comparatively great size and weight per horsepower have made it impractical for anything but marine installations and stationary plants. These two objections — weight and space occupied — have not yet been entirely overcome, so that to date the Diesel engine has been applied in the automotive field only to trucks and motor-busses. However, experimental work with the heavier types of passenger cars has been successful, and suggests that the day may not be far off when the gasoline engine will be almost completely replaced by the Diesel.

Although each of the various makes of Diesel engines being used in automobiles has its own special features, all of them work upon the same principle; so that a general description of the Diesel engine, as applied to the automotive field, will cover any particular model with a fair degree of thoroughness. As is well known, this type of engine uses heavy oil for fuel. Very little refining of the petroleum is necessary. In fact, crude oil, just as it comes from the well, makes fine fuel after it has been filtered or centrifuged to remove sediment. The action of the pistons and valves in an automobile Diesel engine is, with one or two important exceptions, identical with that of any four-cycle gasoline engine. Each cylinder has an air-intake valve, an exhaust valve, and some form of injector or other means to admit fuel.

During the intake stroke, the piston sucks air (not fuel) into the cylinder through the intake valve. The return stroke compresses this air to about 500 pounds per square inch. Just before the instant of maximum pressure, a charge of oil is sprayed into the cylinder in a very finely atomized condition, by means of the injecting device. The temperature of the air in the cylinder has been raised above the kindling point of the oil by the process of compression, and the fuel ignites. The combustion continues during a considerable part of the down-stroke which follows, oil being a much slower-burning fuel than gasoline. During the final stroke the spent gases are forced out through the exhaust valve.

Thus the Diesel engine is basically much like an engine designed for use with gasoline. However, there are four respects in which the former differs from the latter. In the first place it must have some kind of mechanism to measure out just the right amount of oil for each injection. In a gasoline engine the "richness" of the mixture is determined by a simple adjustment on the carburetor; but in an engine where this adjustment must be made *before* the air and fuel mix, a mechanical "metering" system must be used.



The pre-combustion chamber and the special design of the burner, which are shown here, made the diesel suitable for commercial vehicles.

A second difference between the two engines is due to the fact that in the Diesel the fuel enters the cylinder against the pressure of the highly-compressed air within, instead of being aided by a vacuum within the cylinder as in the gasoline engine. Consequently a pumping system must be provided to force the oil through the injector into the combustion chamber of the cylinder.

Thirdly, the engine burning heavy, low-grade oil must have more adequate provision for breaking up the fuel and mixing it with air, i.e. "atomizing" it, than the engine using a very volatile fuel like gasoline. Every Diesel engine has its own arrangement for atomizing its fuel, but a jet, through which the fuel is sprayed into a chamber, is a feature common to practically all of them. In some cases the liquid oil is sprayed directly into the cylinder, and in others into a "pre-combustion chamber" adjoining the cylinder and connected with it by means of a second atomizer, or "burner." In the latter type the fuel is injected into this chamber just before the end of the compression stroke. Ignition takes place immedi-

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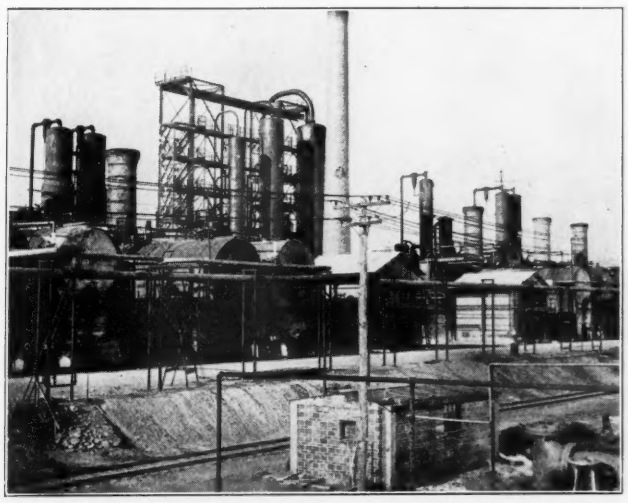
Gasoline

BY NORMAN FITZGERALD, '31

THE oil business of the United States, which is essentially a producer of gasoline and lubricating oil, has grown from birth to an astonishing maturity in the last seventy years. Now it is taking its place among our hugest industrial enterprises, coal mining, metal mining, and non-metallic production.

In 1929, the United States produced 1,006,000,000 barrels of forty-two gallons each of crude oil, 67½% of the world's production, valued at $1,280,000,000. Surprising though it may seem, but little of this vast sea of



One of the many refineries located on the Atlantic seaboard.

oil was produced from gushers; most of it was pumped from the earth in a quiet, unspectacular manner. The 328,200 producing wells of the United States produced at the rate of eight and two-fifths barrels per day, during 1929.

Nearly 30,000 wells are drilled annually. About one-fourth of these are failures and a large number of the others that are listed as productive when they come in soon fall off so that they are unprofitable to operate. The idea that most people have of oil wells is that a hole is dug in the ground with the help of a tall structure known as a crane. The idea of the cost of the relative shallow wells and of the deeper ones that are becoming essential in the mid-continent fields is non-existent. The costs of wells increases in a much greater ratio than the increase in their depth. In 1915, a 2,500-foot well cost about $25,000, but now a 4,500-foot well costs $75,000. Producers have been known to spend several hundred thousand dollars on single wells in isolated districts. There has been an increase in the efficiency of production from the deeper wells as a result of the increased cost of wells so that deep wells, after they have ceased to flow naturally are effectively pumped at much greater depth than formerly, chiefly by the air or gas lift. Practically all of the oil produced in this country is pumped under high pressure through part of our 100,000 miles of oil pipe lines to refineries or to the seaboard, aboard tankers and then to refineries.

Petroleum, in general, is a mutual solution of several series of hydrocarbons such as the straight chain paraffins, the branched chain paraffins, the benzenes, and the napthenes. Small amounts of impurities such as hydrogen sulfide, organic compounds of nitrogen, oxygen, and sulfur are in solution. These often are extremely vile smelling, and the sulfur compounds are usually corrosive.

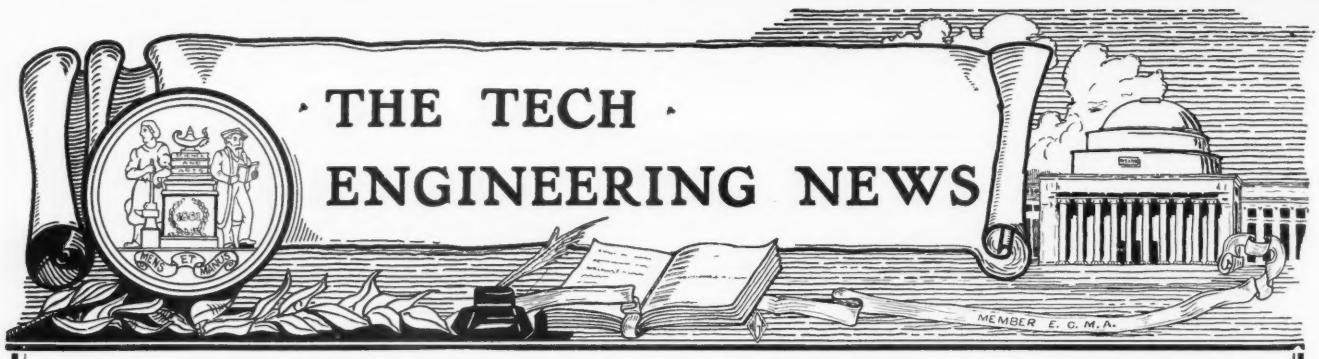
The object of refining is to separate the crude oil into fractions of similar boiling range by means of distillation, and to eliminate the impurities by treating. The products obtainable from the refining of any crude are naturally dependent on the composition of the crude. We expect a wax distillate from a paraffin base oil, and a residual asphaltic fuel oil from an asphaltic base oil, but not vice versa. Possible products from the distillation of a mixed base petroleum are in order of their distillation or boiling range—non-condensable gas, petroleum ether, light gasoline, heavy gasoline, light kerosene, heavy kerosene, furnace oil, gas oil, wax distillate, and an asphaltic fuel oil residuum.

Gasoline which is produced directly from the distillation of crude is called straight run gasoline. It is a colorless, highly volatile fluid of about 72° to 52° specific gravity on the Baume scale. For many years this source of supply was sufficient for the market, but the increasing popularity of the motor car developed a demand for a motor fuel which straight run gasoline could not supply. The World War brought an additional impetus to this need with its many demands for gasoline. The refiners solved the problem of increasing the available gasoline by pyrolysis or cracking of the heavier fractions into gasoline. The decomposition of the compounds of high molecular weight and high boiling point gives compounds of lower molecular weight and lower boiling point, similar to gasoline. For each molecule broken up, in the simple case, an unsaturated and a saturated hydrocarbon are produced.

Cracking takes place in specially designed high pressure stills into which oil is pumped at pressures up to 750 pounds per square inch and heated from 750 to 1200 degrees Fahrenheit. The rate of cracking is a function of the temperature and the amount of cracking is a function of the time. So the refiner has a means of adjusting the process to produce those hydrocarbons

(*Continued on page 314*)

Loading tank cars for delivery to local distributing points.



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Editorials

THE VOLUME CLOSES

With this issue, Volume XI of the TECH ENGINEERING NEWS makes its final appearance. It now becomes our pleasant duty to introduce the men upon whose shoulders the responsibility for Volume XII will rest. The incoming Managing Board is as follows: Clarence M. Chase, Jr. '32, General Manager; Albert G. Dietz '32, Editor-in-Chief; Alfred B. Berghell '32, Business Manager; E. Harold Anderson '32, Publication Manager; Edward R. Atkinson '33, Managing Editor; Donald G. Fink '33, Associate Editor; Wilber B. Huston '33, Associate Editor; Edmund H. Lloyd '33, Advertising Manager; Gene Cary '33, Circulation Manager; Charles E. Buchanan '33, Treasurer. The outgoing Managing Board gives these men their best wishes for success in the coming year.

It is interesting to reflect upon the experiences of the past years on the paper. Every Senior Board in a heavy bull session at the close of the volume invariably decides that they could now publish on their own hook a magazine—one that would make people sit up and take notice. Perhaps it is fortunate for existing publications that no such magazine has ever materialized! Granting that a certain amount of bumptiousness may be inherent in their opinion of themselves, we do feel that the experience is valuable. We have gained contacts not ordinarily granted to the student; we have had a hand in management of affairs; and our dealings with other businesses have in some instances been an education in themselves. We have been free of that disease of student publications known as faculty supervision; consequently whatever knocks we may have had were of our own making, and whatever lessons we have learned therefrom are therefore not likely to be forgotten. Even to a person who will never seen the inside of a business office again the experience is valuable. He ought to be a more practical person than he otherwise would have been, and he ought to be able to talk more freely with business men.

THE TECH ENGINEERING NEWS has played its usual role in the life of the Institute. Following its policy of presenting as interesting a magazine as possible to the students, a number of changes have been instituted. We have changed the make-up somewhat, adopting a two column style in place of the former three columns; this arrangement facilitates reading, as well as offering variety in appearance. A frontispiece is now included in each issue, which we feel adds greatly to the attractiveness of the publication. Our articles have been shortened, and have taken on less technical aspects; the question of the proper type of article to appear in this publication is however debatable, and the proper bal-

ance between value and appeal is often hard to maintain. The publication again played a leading role in the convention of the Engineering College Magazines Associated, held this fall in Bowlder, Colorado, and again received several awards, among them a first prize for covers.

ENGINEERS TO THE RESCUE

Previous to the present administration of the United States, the connection between government and engineering has been remote. In fact, it was a very unusual occurrence that one of the engineering profession should be chosen as our chief executive. More and more, however, is the engineer becoming prominent and indispensable in governmental affairs. With the tremendous speed of today, vast engineering projects are necessitated, and their very vastness calls for the supervision of the central government.

In fact, not only is modern engineering under the administration of the government, but governments are finding out that engineers are very essential to their success. The Soviet Government, which is the most striking example, found itself at its birth in the midst of a ruined land—it was at the helm of a huge nation, notoriously backward and bankrupt. Its foremost aim was to make Russia a great figure in the economic world, and that was the issue upon which it stood. But the solution of this problem presented apparently insurmountable difficulties.

The government, however, saw that it could not stand without economic progress, and economic progress meant the adoption of modern methods, especially in manufacturing. As a result, the engineer was called in to preserve the integrity of the government. American engineers left the foremost industrial nation in the world to aid the great nation of Russia in the development of its tremendous store of natural resources. They carry with them the knowledge that universities and experiences in this country have instilled in them, and in addition the support of some of the greatest engineering concerns in America, if not in the world.

A huge nation has called upon the American engineer for assistance—being able to give no guarantee of financial recompense because of severed diplomatic relations—and he has taken a chance and responded. He will surely justify the confidence that a great though economically and scientifically backward people have placed in him.

RESEARCH VS. TEACHING

For some time there has been posted on the bulletin board of the Department of Physics a type of document rarely seen on Institute bulletin boards. Some disgruntled person taking the Freshman course in mechanics has found it difficult, and having searched his mind for reasons why has posted his conclusions in public. The gist of his thoughts is very simple; the course is made far harder than necessary by using as instructors people who cannot teach.

This is a serious accusation to make. The Institute has an enviable reputation for turning out well-trained men, built on the records of graduates. It would imply that the Institute is in a sense living on its reputation. Such, of course, cannot be the case. The men retained to teach number among them some of the most famous names in the different professions which they represent.

What then is the trouble? We find that the criticism leveled at our instructors is not one peculiar to the Institute. Wherever science is taught, with few exceptions there can the same criticism be made. The trouble is this, that American institutions make an idol of research. This is far from being a fault in itself. It has led to a peculiar conclusion, however, that in order to teach a man must be a good research worker. Success in research is a far more spectacular phenomena than success in teaching. It is at once evident; it will be discussed throughout the scientific world; and perhaps it will strike the fancy of news organs, and thus be brought to the attention of large numbers of people. As the doctrine of "selling one's self" has been infused into American life, these institutions have not escaped. This is considered an excellent result. Students of all sorts are attracted to that institution whose name has beenglorified by the accomplishments of its personnel.

However, it is sad but true, that ability to teach and ability to investigate are not necessary complements. Far from it! The man who possesses both assets is a rare person indeed. It is rather hard on the student to be subjected to a person to whom teaching is an interruption rather than a pleasure. It sometimes seems as if American students learn in spite of the instruction rather than because of it. There are certain students whose intelligence is so great or whose interest is so intense that poor instruction is no deterrent. In a larger majority of cases the student has no fixed idea of his purposes; they gradually form as his contacts with science increase. In such cases the instructor can insure a healthy growth by the enthusiasm he himself feels, or he can kill by his own apathy; he can spur to greater effort by his ability to clarify the mind of the student, or he can choke out desire for progress by his inability to transfer his knowledge to others. It is good for a teacher to engage in research, even if only to assist someone else, for it keeps him up-to-date on his subject matter; but it is not good for a research worker to attempt to teach unless he can.

We have had the pleasure of having with us earlier in the term, Professor Scherrer of the Technische Hochschule at Zurich. Here is a man renowned in the world of physics who is not only an excellent research man but a great teacher as well. His presentation of his subject was remarkably clear; and although the things he said must have seemed ridiculously simple to himself, yet he apparently never lost interest in them, and some of his own enthusiasm was automatically transmitted to his audience. We feel that the type of person represented by Professor Scherrer ought to be the ideal sought in a teacher.

THE NEW BUILDINGS

Professors having classes in the vicinity of Buildings 2, 4, and 8 discovered one morning before Christmas vacation, that for some time to come they would have to talk down a steam shovel. In other words, the construction of the new Physics and Chemistry buildings is fairly under way; we hope that the practise the instructors will get in drowning out the steam shovel will aid them in competing with the riveting operations to follow. This is all in a good cause, however, for the new equipment will give the Institute an even more prominent place in the world of science. The addition of the new buildings, particularly that of the Spectroscopic Laboratory, indicates that leadership in research is still with the educational institution. The unbelievable rapidity with which commercial organizations established laboratories, coupled with the immense resources available to them, made one wonder whether they might dominate the field. The educational institution has, however, a freedom in the selection of fields of investigation which is lacking elsewhere.

Engineering Notes

The Largest Steel Plate Wye in the United States and probably in the world has just been delivered to Seattle's Diablo power dam on the Skagit River in Northern Washington. This giant penstock is constructed of three-quarter inch steel, 65 tons of plates being used in this section of it. It is reinforced by three steel bands, 21, 25, and 30 feet in length. The diameter of the main sections is 19.5 feet while each of the smaller sections measures 15 feet in diameter. The wye was shipped to Diablo in sections for assembly.

The water will be brought through a 2,000-foot tunnel, 19.5 feet in diameter from the reservoir back of the dam. At the mouth of the tunnel it will enter the steel penstock which will be embedded in reinforced concrete. Through the immense pipes, two streams of water, each 15 feet in diameter, will drop 189 feet to the power house where each stream will drive a 95,000 H.P. generator. The head of water from the dam to the water wheels will be 325 feet. The height of the section is 33 feet while the breadth at the broadest portion is thirty feet.

Oil Recovery from metal turnings and drillings in factories where a great deal of machining is done has long been a very vital problem. Heretofore, the oil which is used on the cutting tools to prevent overheating, and which in turn saturates the turnings and drillings, has been almost entirely wasted because of the lack of a suitable means of recovery. One method which has been tried in some factories is to pass the turnings and scrap through a rotary screen which retains the turnings and allows the oil to drip through. This method, although satisfactory enough to pay for itself, is usually very inefficient.

A novel method for oil recovery has been put into operation by several progressive manufacturers and has been found to give very nearly the theoretical yield of pure oil from the turnings. The method involves the use of rotary centrifuges into which the oily scrap is emptied. Due to the high velocity of the centrifuges, the oil is thrown off of the metal particles and is driven out of the machine through a spout. The oil is allowed to stand to separate out any small particles of metal that may be present, and is then filtered and returned to the pure oil reservoir for use again in cooling cutting tools.

The Deflection of Rails of street and other light railroads is accurately determined by a deflectometer which has recently been developed. It consists of a lever, the arms of which are about five and twenty-five inches long. The shorter arm is connected to a clamp which is securely fixed to the rail; the longer arm carries a pencil which bears on a piece of paper. The whole is supported on pipes driven into the ground to a sufficient depth to eliminate vibration. If the ground is paved, the paving is cut away so that no vibration is transmitted to the lever by the support.

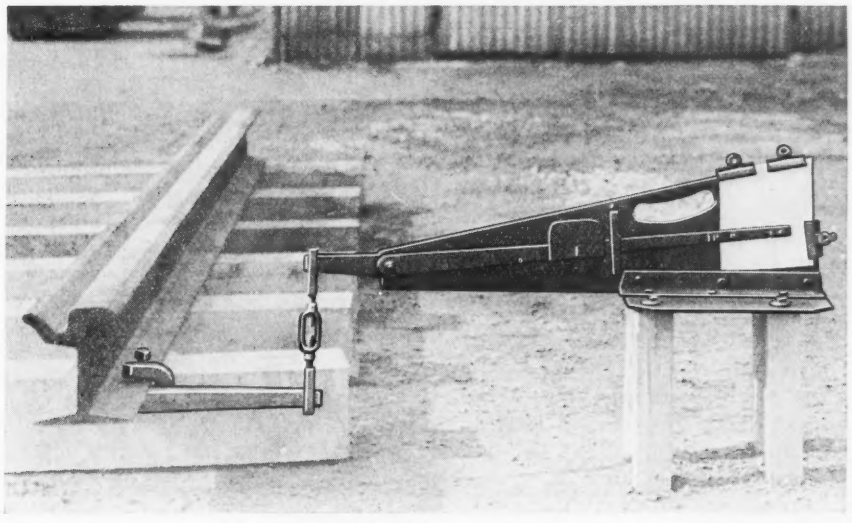
The Value of Rubber as a protective against corrosion and abrasion has long been known but the difficulty in the practice of the above has been the fact that it was an expensive proposition to attach it to the various types of surfaces needing protection. However, by a recently perfected process, the difficulty is said to have been overcome. This is accomplished by the use of a soft plastic rubber compound to attach the rubber to metal, brick, wood, or cement surfaces without the use of heat, steam, or pressure. This compound, on exposure to air, readily vulcanizes itself and forms a permanent rubber coating on the surface to which it is applied. It can be obtained in various colors and in two forms, as a paste for application anywhere, or in sheets already vulcanized to a fabric or wire mesh brace. In either of these forms it can be easily used and is not affected by the weather.

Courtesy, Power

This huge steel wye is the largest in the United States. It is part of a large penstock, the greatest diameter being nineteen and one-half feet.

An Iron Base Highway is being laid in Illinois for test purposes, the object being to obtain a road which will not crack. The road will have a carefully rolled sub-grade on which the iron base will be laid. Upon this will be placed a layer of mastic sand and finally a surface of three-inch brick. The iron base will consist of three fifty-foot sections; one will be blue annealed flat sheets, and the others galvanized and corrugated sheets. The corrugations in one fifty-foot section will be laid parallel to the road while in the others they will be transverse. The flat iron base will be one-half inch thick and the other bases will be ten gauge.

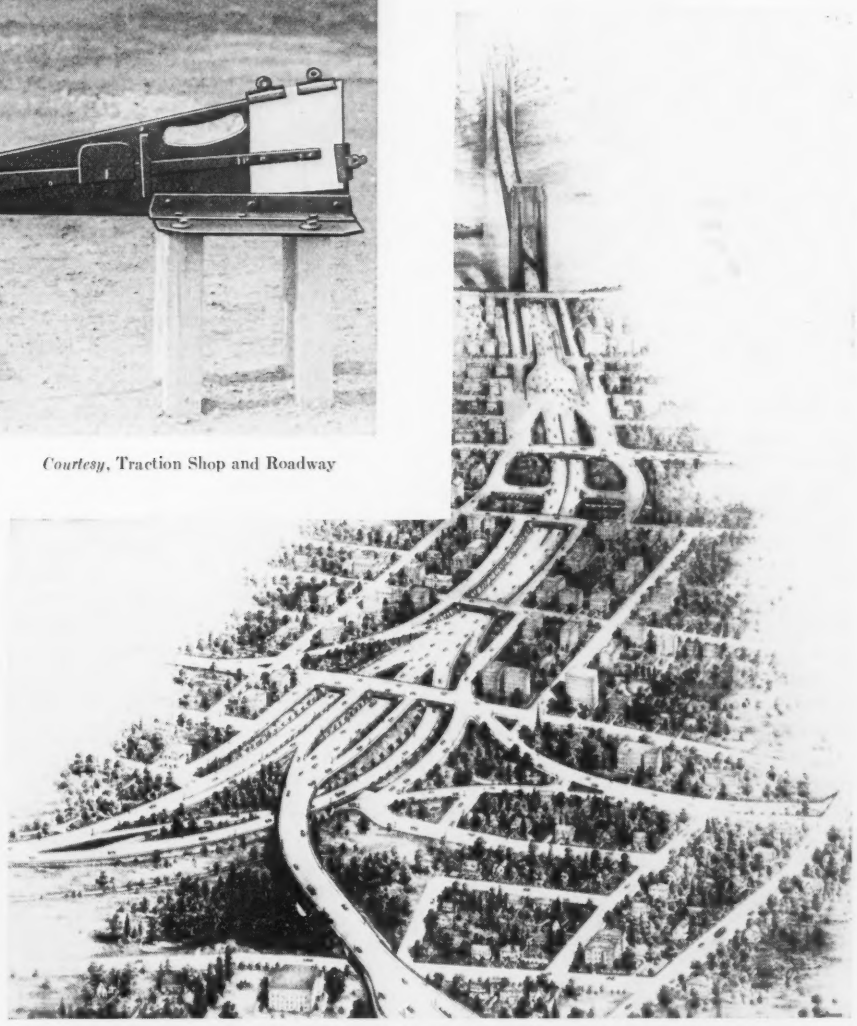
The Hudson River Bridge at Fort Lee, New Jersey, will have upon completion a very interesting and complicated system of approaches, designed to afford the maximum flow of vehicles across the bridge. The approaches in design resemble a vision of the future. All left-hand turns have been eliminated by the building of underpasses which will turn to the right, off of the main highway, and then curve left under the main thoroughfare. A feature of the design of the approaches to the bridge is the construction of a three-level highway which will continue for two or three miles from the bridge itself.



The deflection of a rail under load is measured by this instrument making a permanent record on the paper pad on the right.

Courtesy, Traction Shop and Roadway

The purpose of these elaborate approaches is to facilitate the rapid movement of traffic onto and off of the bridge in order to prevent congestion of the through traffic by cross traffic from the minor arteries. Because of the elimination of unnecessary delay, it is expected that a flow of vehicles will amount to eighty thousand per day. This is by far the greatest flow over a single bridge that has ever been possible. This method for eliminating traffic congestion was adopted after careful investigation into the causes of bridge obstruction.



Courtesy, Engineering News Record

This complicated system of approaches to the Fort Lee Bridge is designed to maintain a fast flow of traffic with the maximum amount of safety.

The World's Largest Truck is now being used in England. The newest leviathan of the road is built to haul load of 100 tons, which would enable it to move a small locomotive across the country. The truck's enormous weight is distributed upon ten solid rubber tired wheels. Because of its size, a special permit was necessary to drive the truck on the highways, and it can be used only at night when traffic is light. The truck is operated by a crew of two, the driver and an assistant who sits at the rear and telephones the driver when to turn to the side of the road to let motorists pass.

A Demountable Track which can be placed around the four rear wheels of the typical six-wheel truck whenever the load is in danger of being mired in soft ground or embedded in sand has just been marketed.

The track consists of a series of pads made of welded bits of nickel steel linked together into a continuous chain with nitralloy pins. The pinholes and bosses of the pads as well as the pins are nitrided to resist the wear of gritty particles which inevitably find lodgement at all rubbing surfaces. (The pads are tinned by dipping them in molten metal and the coating is then machined off those surfaces which are to be hardened.)

This demountable track is not only light and easily put on and taken off, but is also unusually sturdy and will withstand more wear and rough handling than any type yet developed.

A Propeller-Driven Rail Car has been developed in Germany. It is claimed that it will attain 185 m.p.h. and that it has attained 124 m.p.h. on a tangent near Hanover. It is of streamlined design, and weighs about 20.5 tons. The length is 85 feet.

Power is supplied by a 500 H.P. airplane engine, which is said to be twice as large as is necessary. This drives the four-bladed propeller at the rear. Four and four-tenths miles per gallon of fuel are obtained. There are two axles, 65 feet apart. Its lowered resistance accounts for its increased efficiency.

Departmental Notes

One of the more important cares of an institution of higher learning is the health of its students. In this respect, the work of the Department of Hygiene is to be commended. The physical examination for all students, which until two years ago was required of freshman only, is amply justified and the value of the Homberg Infirmary fully demonstrated.

Two important new courses will be offered next year, one to provide training in geodesy and the other in seismology. In the former course, work already undertaken in the Department of Civil Engineering will be expanded for further study of the vitally interesting matter of earth movement. In seismology, the study of earthquakes, interest will be centered not so much on earthquakes alone as on the development of new knowledge of their various forces and of their effects on engineering structures such as bridges, dams, and towering modern buildings. The proposed course will be based on fundamental physics and engineering subjects. From it should come, in the future, valuable contributions to the design of structures able to withstand earthquake shocks. A seismograph of new design is now under construction and will probably be installed at the Institute's civil engineering camp near East Machias, Maine.

Closely allied to these proposed studies is the present work being carried on in soil mechanics, a branch of engineering concerned with foundations and other earthworks, that is attracting wide attention in the engineering world.

The recent establishment of a plumbing laboratory at Technology, is an indication that with the tremendous advances in building construction and the design of buildings of great heights, there is a definite need for scientific and technical knowledge in this field of sanitary engineering.

There is great demand for graduates of the Department of Mechanical Engineering. All seniors and graduate students of last year had secured positions before their graduation, and fifty per cent more could have been placed had they been available. The work of the laboratory for testing materials in this Department has expanded and new equipment has been installed. The textile laboratory has also developed rapidly and important research in the textile fields is being carried on.

The work of the metallurgical engineer in recent years has revolutionized some industries. The importance of metallurgy from which have come so many valuable alloys has increased at such a pace that the demand for experts in this field exceeds the number it has been possible to train. The Institute's Department of Mining and Metallurgy is not only training for this profession, but is also carrying on research of great importance. That young men are awakening to the rich opportunities in this field is indicated by the fact that registration for metallurgical courses has increased.

The honors group plan of the Department of Electrical Engineering has been so successful that its continuance on a permanent basis has been authorized, and it is hoped that the plan in a modified form can be applied in other Departments. Under this plan students of exceptional ability are given more freedom in the selection of professional subjects for study and the work can be adjusted to the requirements of the individual.

THE Tech Engineering News here presents in lieu of the regular Departmental Notes an abstract of the annual report of the president of the Institute. This report was recently made to the corporation by Dr. Samuel W. Stratton who, until his appointment as Chairman of the Corporation last June, was President of Technology.

In the report, a survey is made of the activities of the Institute during the past academic year up to the beginning of the administration of Karl T. Compton.

The past year at Technology has seen many foreign lecturers of distinction in various fields of science and engineering. Authorities on a great variety of technical subjects have been invited to lecture to the Institute for the benefit of the staff and students. In addition to these leaders in science, executives and engineers representing the great industries of the United States have frequently lectured in various Departments, bringing to the faculty and student body the viewpoint of the leaders in their various fields, and the immediate problems of the times.

Among the achievements of the Department of Architecture may be mentioned the excellent record of graduates, who in the past have been awarded many of the most coveted prizes in the profession, including during the year the Rotch, the Guy Lowell, the Kelley and the Paris Prizes. The latter, perhaps the most distinguished of all, has been won by a graduate of the Department for the third time in four years.

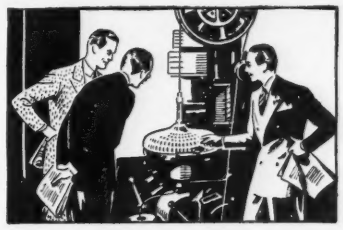
Progress in the Department of Aeronautical Engineering has been most satisfactory, and in addition to the various courses, much research of fundamental importance has been carried on. During the year a new five-foot wind tunnel for instruction and research has been in operation. Among the investigations carried on by the Department were studies of slotted airplane wings, the design of high wing airplanes, the stability of rigid airships, and important research on the subject of aircraft power plants.

The course in building construction is meeting the demand for men trained for advanced positions in the building industry. This course gives training in the various aspects of actual construction, such as the assembly of materials and construction methods, with a definite understanding of the relationships between the architect and the engineer, and the most efficient utilization of labor.

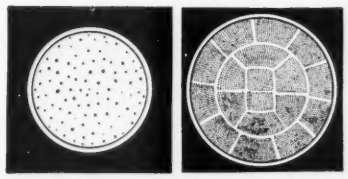
The work of the new hydraulic engineering laboratory, established during the past year, has included a number of important problems which have fully demonstrated the need for research in a field, which, while new in this country, has long been carried on in European laboratories. Members of the staff at Technology have studied in Germany and other continental countries, and their knowledge is now being applied in the work here. The studies that come under this laboratory include power development, turbines, rotary pumps, propellers, river and harbor control, dams, and other forms of hydraulic engineering. There is great need for the application of knowledge in this field to solve the many problems of river and harbor control in the United States. Interest in the work has been increased by lectures at the Institute by various authorities on hydraulic engineering.

The demand for men trained in the field of chemical engineering is rapidly increasing, and the course has

(Continued on page 320)

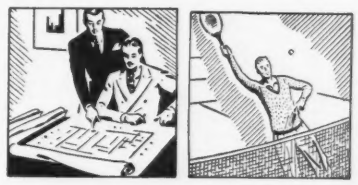


They made 36 wires grow where only one grew before



Yesterday, the 100 wire cable— today the 3636. Development work goes steadily forward.

"No product or process is ever beyond improvement", say Western Electric manufacturing engineers. For example, see what they did with telephone cable... Through years of patient trial they advanced from a crude 100 wire cable to one only slightly larger which contained 2424 wires—until recently the biggest cable that could be laid in existing conduits... Still further effort produced the 3636 wire cable of exactly the same diameter as the 2424! Thus they have met the challenge of limited space in crowded cable ducts and have supplied facilities for constantly greater use of the telephone . . . There's a real thrill in this habit of seeking and finding the new and better way!



Absorbing work plus out-of-hours recreation — both are found at Western Electric.

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SINCE 1882 FOR THE BELL SYSTEM

Bachrach

PROFESSOR WILLIAM SPENCER HUTCHINSON

Head of the Department of Mining and Metallurgy

Professor William Spencer Hutchinson, Head of the Department of Mining and Metallurgy since 1927, has had the distinction of becoming a leading educator after a long career as mining engineer and consultant. A graduate of the Institute in the class of 1892, he has had since that time a wide experience in his profession, ranging from ore-shoveler to his present position.

An interest in outdoor life led to his choice of mining as a career, but the panic conditions which existed at the time of his graduation made securing a worthwhile position very difficult. After a year as Assistant Secretary of the Faculty, nevertheless, he departed for California, intent on entering mining. His first job was that of ore-shoveler at two and a half dollars per day. The progress from this job was rapid, however, and he soon graduated from the mine to the mill. Some years later he returned East to his home in Boston. There his practical experience and executive ability earned him the job of Superintendent in Missouri, in the year 1899, where he remained until four years later. The year 1903 marked the end of his activity as a mine operator. During these ten years he gained the practical knowledge of labor and mining conditions which are essential to a well-grounded consulting practice.

In 1903 he "hung out his shingle" as a mining consultant in Boston. Thus began a career of twenty years in this field during which he built for himself a nation-wide reputation. During the first few months of his consulting practice, a mining concern made inquiries at the Institute for a man who could do some specialized consulting work. The Secretary of the Faculty in recommending Professor Hutchinson, who was comparatively unknown at the time, said that he was willing to recommend him for anything he was willing to undertake.

Professor Hutchinson created the office of operating consultant, that is a consultant whose main activity is the control of design and operating of mines, especially in the coordination of widely separated workings. The income tax law which required the evaluation of mine properties opened up a large field in which he soon became a leader. This experience strengthened his grasp of the economics of mining.

On January first, 1923, the same day that former President Stratton assumed office, Professor Hutchinson entered the faculty of the Institute as Professor of Mining. Although he had no previous experience in this field whatever, and was at the time fifty-two years old, he displayed so much ability, especially in administration work, that four years later he became head of the Department.

Today Professor Hutchinson has an ideal background for teaching and administration. Ten years of the practical problems of mine operation and twenty years of the economic principles with which a consultant must deal have given him a view of the field which few men can claim to possess. In teaching his graduate courses he lays particular emphasis on economic problems, because, as he says, the engineering of a mine may be perfect, but if the ore is low-grade, or the market doubtful, failure will often result. An attempt is being made in the Department to teach the students those facts which they cannot pick up from the mine foreman or the boss timberman in their first weeks of practice, that is, the economics of mining.

Professor Hutchinson has a deep personal interest in the students with whom he comes in contact. His abundant energy and confidence in himself and his profession make him a man well able to advise students in their problems. His popularity both within his Department and in Institute affairs at large bear witness to his success.

Speed Boat Design

(*Continued from page 299*)

The actual shape of the bottom is, of course, the most important factor in the performance of any boat. It must be designed to combine maximum lift with minimum disturbance of the water, that is, wave making, and at the same time reduce the wetted surface, and correspondingly the frictional resistance, as much as possible. A different method of attaining these results must be employed in each different type of boat so that it will be impossible to describe them all at this time. I will, therefore, go into some detail only on the highest speed type, namely the vee bottom with one transverse step. In any boat, except the smallest outboards, it is impossible to decrease the wetted surface to a minimum without a step because the hull would be unstable if the small amount of planing area, necessary at high speed, was all located in one place. For this reason the bottom is divided into two planes, separated by a step, so that the planing area is divided and not centralized in one place. The leading edge of the forward plane causes most of the wave effect and therefore it must be carefully shaped in order that it will throw the water aside with the least possible resistance. This shape must be carried well above the normal water line so that it will add as little resistance as possible when meeting a wave which, at high speed, will cause excessive pounding as well as checking the speed.

Water, as well as any other body, when given an initial velocity and allowed to fall will describe a parabola and for this reason the sections of the forward plane near the leading edge should be parabolic in order that the water may follow them with the least resistance. This shape must be in the direction of the flow of water which varies from 60 to 35 degrees, to the center line of the boat, as the speed increases. The shape of the curve also varies, becoming flatter as the speed increases and it is therefore possible to produce a set of curves which the water will follow very closely at varying speeds. If the correct curves are used the water will exert a small constant pressure throughout its travel and it is very important to prevent it from breaking away from the bottom at any point as this will cause a negative pressure area. This entire forward part of the plane would be unnecessary if the water were always perfectly smooth and the boat were not required to turn sharply, but for ordinary service it must be used in order to break the waves and give stability on the turns. Even with this a small fin is usually fitted under the forward plane to give greater manoeuverability.

The forward parabolic sections give very little lift and must be faired out into a flatter plane as they go aft. This is the part of the bottom which exerts the greatest lift as the water has been smoothed out to a great extent by the leading edge. The aft plane can also be nearly flat because it is acted upon by a reasonably constant flow of water which has left the forward plane at the step. The experience gained from a number of tests shows that a well-designed bottom is about 40% as efficient as a small flat plane and therefore the expression for the normal pressure on any given bottom plane is $P = .62\ KAV^2$ where K varies between .10 and .30 as the plane angle increases, A is the area of the plane in square feet, and V is the velocity in feet per second. This normal pressure multiplied by the cosine of the angle of attack gives the vertical component, or lift, expressed in pounds and is applied at the center of gravity of the plane. While dealing with the lift it must be remembered that in most high-speed boats the propeller

(*Continued on page 311*)

Speed Boat Design

(*Continued from page 310*)

shaft will have an angle of 10 to 20 degrees to the horizontal. The total thrust may be divided into two components; a horizontal one which is the effective thrust, and is equal to the total resistance, and a vertical one which must be added to the lift of the planes. This component will be equal to the thrust multiplied by the sine of the shaft angle and is applied at the thrust bearing. The total number of pounds lift should almost equal the weight of the boat and therefore may be used to check the area of the wetted surface. Also the location of the point at which it is applied is almost essential in determining the running trim of the boat.

The foregoing methods and formulae are about all that the designer of a fast boat will find of any use in helping him determine the shape of a hull. It is a regrettable fact that careful experiments along this line have been so limited that none of these formulae can be considered absolutely accurate. However, they serve as an excellent check on his work and should form a sound basis from which, it is hoped, further experiments will be carried on.

Railway Electrification

(*Continued from page 301*)

ting in the metropolitan district and in the West is sent for consolidation into through cars and dispatched to countless destinations throughout the West or to destinations in the New Jersey and New York metropolitan district, as the case may be (accommodations for 3,800 cars being provided); where coal and other freight is also handled, extra cars stored, etc. Between these two points there is, naturally, an almost continuous back-and-forth movement of freight. While the main line and passenger terminal tracks were being electrified, the company embraced the opportunity to electrify two of the tracks from West End, the purpose being to eliminate smoke in this terminal area and at the same time permit of decreased time intervals between the operation of multiple unit suburban trains.

The Secaucus yard presented several difficulties to the erection of overhead. The railroad overcame these through the use of a uniquely designed type of electric locomotive and purchased from the General Electric Company two 124-ton trolley, oil-electric battery locomotives constructed to operate from power supplied by 300 H.P. oil engines, driving 750-volt generators which can be used to charge the 360-cell batteries and also supply power to the traction motors, or storage batteries carried on the locomotives and also to operate from external power collected from the 3,000-volt trolley.

These "three-power" locomotives are the first of their type built in the world. The traction motors, as designed, represent a higher output per pound of material and mounting within a smaller space than any motors of their type and voltage in operation in the world. The maximum permissible speed of these locomotives is 40 miles per hour.

BAILEY METERS

BRAINS FOR BOILERS

A few years ago when a steam power plant underwent a heavy load demand, grimy firemen would work feverishly to keep pace with the cry for more steam. By their back breaking labor, six men could bring twelve 100 H. P. boilers from bank to full load in one hour. Coal and air were fed to the furnaces with little regard to combustion efficiency.

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Write for Bulletin No. 12

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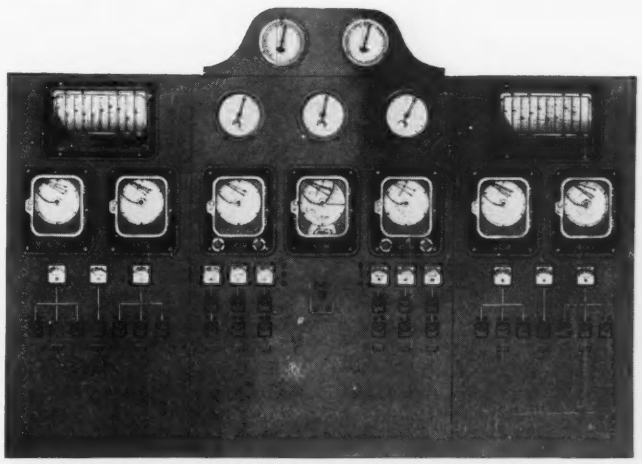

BAILEY METERS AND CONTROL ON A 1350 LB. PRESSURE BOILER

Automobile Aerodynamics

(*Continued from page 294*)

late Professor E. H. Lockwood, of Yale University, obtained in 1928 remarkably uniform and consistent results for a variety of cars by means of the second method.

Very noteworthy results have been obtained with the third method by Professors T. R. Agg and Noah Wolfard, of the Iowa State College and the Oklahoma College of Agriculture and the Mechanic Arts, in 1926.

The full-size wind-tunnel method was used for improving the design of racing cars, some ten years ago, in the large wind tunnel at Issy-les-Moulineaux of the French Army Section Technique d'Aeronautique, and by Professors L. E. Conrad and E. R. Dawley, in a special large wind tunnel at the Kansas State Agricultural College, in 1925 and 1926. This method has the disadvantage of impossibility of determining the ground effect (to be explained farther in this article) upon the air resistance of an automobile moving along the road.

The fifth, and last, method is perhaps the oldest and most promising. Eiffel tested models of automobiles, locomotives and railroad coaches as far back as 20 years ago, in his aerodynamic laboratory in Paris. He soon realized the necessity for reproducing in these tests the effect of the ground moving relatively to the car, but did not find a satisfactory way of doing it. This difficulty was solved by the application of the so-called *principle of aerodynamic reflection*, now used in such tests, and the writer is indebted to Mr. E. P. Warner, former Professor of Aeronautical Engineering at the Massachusetts Institute of Technology, for the information that the method of aerodynamic reflection was used by Professor Ober, also of the Massachusetts Institute of Technology, as far back as 1916 in connection with his study of air resistance of ships.

This method, as applied to automobiles, consists in using two models of the automobile, their wheels touching and the bottoms facing each other.

In this way, in the plane of symmetry of these two symmetrical bodies, a rectilinear flow of air is obtained, as along the smooth surface of the road. This method of reproducing the ground effect, while not ideal, is the best we know of.

According to tests made by Miss MacGill, graduate student in Aeronautical Engineering at the University of Michigan in the year 1928-1929, the ground effect on the air resistance of automobiles varies gradually with the speeds from 60 to 90 mi./hr.

from +21.2 to +15.3 in a phaeton with curtains up
" +14.5 " +12.6 " " " " " down
" +3.0 " +3.3 " " coupe
" −3.0 " −5.5 " " sedan

This means that in predicting the air resistance of an automobile on the basis of a wind-tunnel test of a single model (without ground effect) the resistance so determined will be as many per cent in error.

Of course, such tests should include the measurements of the lift component of the total air reaction on one of the automobiles of the combination. This lift may be positive or negative and of different value on the front and rear axles.

The ideal case would be in such a shape of the automobile that it would produce neither positive nor negative lift with the ground effect and thus eliminate entirely the induced drag item from the total air resistance. This might be not fully possible in pleasure cars, but quite possible in racing cars in which the question of air resistance is of particular importance.

A reduction of the eddy-making drag item can be accomplished by streamlining of the cars; however, this would lead to shapes which would increase greatly the already acute parking difficulties. Fortunately, a compromise treatment of streamlining offers very interesting possibilities, and already is breaking into use in modern car body design.

According to tests made by a group of students in aeronautical engineering at the University of Michigan, with a parallelepiped approaching roughly the proportions of a sedan body, namely, 12 x 12 x 21 inches, at wind velocities from 60 to 90 mi./hr., the rounding of edges and corners may reduce the value of the coefficient of air resistance as much as 80%, in comparison with the sharp edged parallelepiped, and beveling of flanks can reduce the coefficient more than 60%.

Further appreciable reduction of air resistance can be obtained by certain modifications in the design of radiators, sun visors and fenders, slanting of windshields, streamlining of wheels, fairing of axles and cross members in the chassis, etc. All this will very likely come into use gradually, with the popularization of principles of aerodynamics among the car designers.

Streamlining of automobiles, however, should be more extensively studied for the effect of lateral winds, before more radical departures from the present designs will be decided upon. At high translational speeds, in strong lateral winds, serious yawing moments may come into play, impairing the directional controllability of the car.

Striking and very noteworthy examples of streamlining of motor vehicles (pictures of which have been published recently in this country) can be found in the new French autobus operated between Paris and the sea resorts at 85 mi./hr., and the German motor railroad car operated by an air propeller at 100 mi./hr., at comparatively little power expenditure.

In conclusion, therefore, when studying the effect of some changes in design, the wind-tunnel scale-model method lends itself as the most advantageous, since a great variety of modifications can be studied as to their *comparative value* at much less expense than it could be done in the case of experimentation with full-size cars; ignorance of the scale effect is here of little importance. When, however, an accurate knowledge of the full-size value of the resistance coefficient of a given vehicle is necessary for any reason, the scale-correction coefficient could be determined by tests of a representative design in a wind tunnel, using double models for ground effect, and from the full-size tests by the coasting-downhill method.

Hot Springs have been piped by the engineers of Iceland to furnish heat. The plant now heats the National Hospital, a school, and an indoor swimming pool in Reykjavik, and plans have been made to heat the entire city.

The pumping plant is located at the geyser and is equipped with three electrically driven centrifugal pumps. The water is first pumped to a large storage tank and then conveyed to the city through small-diameter, seamless steel pipe which is fitted with expansion joints every 165 feet. To prevent any great loss of heat through radiation, the pipe is wrapped in a layer of cork which is then covered by successive layers of concrete, asphalt, jute and felt. A large storage tank is located in the city to take care of surplus water at night when radiators are shut off.

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Gasoline

(*Continued from page 303*)

most suited to his needs. The usual products are a large amount of gas similar to natural gas, a medium gasoline and a heavy fuel oil.

Hydrogenation is a new development in petroleum technology which will give us a barrel of gasoline for a barrel of crude if necessary, but at present the process is not profitable. Essentially, hydrogenation is the cracking of heavy fractions into lighter hydrocarbons in an atmosphere of hydrogen, so that the unsaturated compounds will add hydrogen, making up their hydrogen deficiency, and become similar to ordinary gasoline. Hydrogenation will become an increasingly important factor in the refining process, probably becoming commercially applicable to the treatment of cracking still residual oil within a short time.

A good gasoline has certain essential qualities, just as a good steel has, but a good steel for structural purposes may be a poor steel for watch springs; so it is with gasoline. Each refiner emphasizes as most important those specifications which his product meets with the least cost in refining, but there is no one best set of specifications. A high rating in all desirable characteristics is incompatible with the nature of gasoline, and the best suited motor fuel must be selected for the specific purpose. The refiners' usual tests are, in general, distillation, anti-knock, gum, sulfur, corrosion, doctor, color, odor, and specific gravity. Distillation tests give an index of the pep and energy of the gasoline; the anti-knock value is proportional to the anti-detonating qualities of the gasoline; gum, a measure of gum formation; sulfur, doctor, and corrosion tests are a measure of actual and potential corrosiveness; color and odor are demanded by the dealer and the specific gravity gives a rough indication of the nature of the gasoline when the crude is known.

As a result of a comprehensive set of experiments carried on by the U. S. Bureau of Standards on the adaptation of gasoline to internal combustion engines, the refiners are producing a more or less "anti-knock" gasoline. By this is meant a fuel in which the tendency to knock (i.e. to develop a metallic "ping" when the engine is under full load or badly carbonized) is greatly reduced. This property of gasoline is determined in some instances by the nature of its hydrocarbons by the addition of benzol or of small quantities of tetra-ethyl lead which retards the speed at which combustion takes place. When the fact that the average engine converts into available power only 5% of the energy of the gasoline which it consumes is realized, the possibility of other efficiencies in motor fuel utilization is evident.

Cracked gasoline contains unsaturated compounds, the olefines and the diolefines. As it comes from the pressure stills it has a strong acrid odor, a dark color, and a high potential gum. The consumer demands a sweet smelling, water-white distillate with low gum content, so cracked gasoline must be specially treated to eliminate the unsaturates. Unfortunately the treatment is wasteful because the unsaturates and aromatics, which are removed with them, are of high fuel and anti-knock value. Agitation with sulfuric acid polymerizes the unsaturates and forms water soluble alkyl hydrogen sulfates with them, water soluble sulfonic acids with the aromatics, oxidizes some high boiling constituents and combines with the organic coloring matter. After settling, the gasoline is drawn off, washed with water, with weak caustic, and with water, to eliminate the acid. To stabilize the color, reduce the gum, and get a lower end point, many refiners re-run it, taking it off the stills with straight run.

Straight run gasoline is treated to remove the sulfur compounds which are corrosive or become so on combustion, to improve the color and odor. Agitation with doctor solution, litharge and caustic forming sodium plumbite, precipitates lead sulfide which carries down combined sulfur, absorbed organic sulfur compounds and adsorbed coloring matter. This treatment forms lead mercaptides with the mercaptans or thio-alcohols which are precipitated as lead sulfide upon the addition of native sulfur. After settling, the gasoline is drawn off, blended to give it the correct distillation test, and anti-knock compounds and dyes added to bring the product up to specifications.

Gasoline after blending and testing is ready for shipment. Local shipment is by tank truck of about 1,000 gallons capacity; inland shipment by tank cars of 8,000 to 10,000 gallons capacity; coastal shipment by barges of about 500,000 gallons capacity and ocean shipment in tankers of up to 6,000,000 gallons capacity. At the present time there are several gasoline pipe lines, and the future will see many more. When these lines are supplemented by barge transport on our inland waterways, even cheaper than pumping, our 275,000 tank cars will not be so essential.

Gasoline usually is the most valuable fraction of the crude, but the products actually obtained from the crude are many and varied. Motor fuels, burning oils, ink oils, lubricating oils, wax, coke, solvents, and alcohols are but a few of the myriads of possible products. The influence of these and other petroleum products upon present-day industry is great, and with the progress of synthetic organic chemistry, the increasing economic importance of the natural hydrocarbons is assured.

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The Bonnet Carre spillway consists of a concrete dam and a pier-and-weir section about 7700 feet long. The weir sections, which are twenty feet wide between the piers, have timber needles on the crests at two levels — elevations 16 and 18 A traveling crane, on a bridge spanning the piers, removes the timber needles for discharge.

N. E. C. equipment played an important part in the construction set-up. Two Koehring Cranes handled aggregate at the material bins and a third Koehring placed the concrete with an Insley bucket. Two large Smith mixers mixed the 127,000 cu. yds. of concrete used on the project.

Wherever you find construction work in progress, you find N. E. C. equipment!

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Diesels for Automotive Power

(*Continued from page 302*)

ately, for the compression in the cylinder has been communicated to the pre-combustion chamber through the burner, and consequently the temperature in the chamber is well above the kindling point of the oil spray. When the fuel starts to burn, the pressure in the pre-combustion chamber is greatly increased and the partly-burned oil, already fairly well atomized, is forced through the burner into the cylinder and completely vaporized by its passage through this second atomizer. The remaining part of the process of combustion now takes place within the cylinder.

Finally, the fourth difference between Diesel and gasoline engines is the absence of an electrical ignition system in the former. Some Diesels, to be sure, have glow plugs built into their pre-combustion chambers. These are resistance-wire devices operating from the storage battery of the automobile; their function is to warm up the pre-combustion chambers and thus make starting easier in cold weather. An ignition system, in the real sense of the term, does not exist in a Diesel engine.

A typical Diesel engine used in the automotive field is a German 6-cylinder Crude Oil engine, developing 72 H.P. at 1,650 r.p.m. This power plant is already in commercial use as an integral part of a chassis built by the same company, for heavy trucks and motorbusses. This engine is a good example of the pre-combustion chamber type, using glow plugs to facilitate starting in the cold. The fuel pumping system is of a type quite commonly used. Six individual plunger pumps are grouped together and operated by one cam plate; each of these fuel pumps supplies the injector of one cylinder with oil. All six fuel pumps are supplied from the main fuel tank by a fuel supply pump. The amount of oil delivered by the fuel pumps is regulated by the accelerator and hand-throttle, and by a centrifugal governor which makes it impossible to exceed 1,700 r.p.m. Starting a Diesel engine is not a complicated process, as is shown by the fact that this motor is equipped merely with an electric starter, engaging in the usual way with the rim of the flywheel, and operated exactly like the starter of a gasoline automobile engine.

Although the application of the Diesel engine to private passenger automobiles is still in the future, some very interesting experiments have been made by an official of an American company, using a 4-cylinder Diesel engine with a normal speed of 1,000 r.p.m. Early in the spring this engine was installed in a large sedan, weighing three tons when ready for a trip, which was driven from Indianapolis to New York. Snow, ice and traffic made the trip a hard one, but the Diesel-powered car behaved very well. Later the engine was taken from this sedan and put in a roadster weighing about 4,500 lbs. This car was then driven from Columbus, Ind., to Daytona Beach, Fla., a distance of 1,060 mi., on 39 gals. of fuel. The mountain climbing ability of the car was tested on Lookout Mountain, Tenn., and found to be very satisfactory. The acceleration of the Diesel-powered roadster was also found to be remarkable, surpassing that of most gasoline cars. At Daytona Beach a speed test was made, and the car made a record of 80.389 mi. per hr., which it later raised to 88 mi. per hr. Thus there seem to be many possibilities in the idea of using the Diesel engine for even light passenger cars.

What are the advantages of the Diesel engine, as compared with a gasoline power plant? In the first place, the cost of fuel is much lower, due to both the greater mileage per gallon and the lower grade of fuel which can be used. In the second place, the elimination of the electrical ignition system does away with a large part of the gasoline engine's ills. Finally, the fire hazard, an important factor in automobile insurance rates, is almost zero. With these advantages over the gasoline motor, the advent of the Diesel engine in the automotive field is inevitable.

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Blasting Poles into Position has proved very effective for setting poles in "plastic" soils, in swamp lands, and at considerable distances below water surfaces where it is difficult to prevent holes caving in before the poles can be set. The method consists of vertically driving an inch and a half hollow drill into the ground to the depth to which the pole is to be set. The soil in the drill is then forced out at the bottom end of the drill with a ram and the blasting charge dropped into the drill. The drill is withdrawn and the pole is placed vertically into position, resting on the surface of the natural soil and directly over the charge. The charge is detonated and the pole drops into the gas pocket created by the explosion. The natural ground and the water pressures force the soil solidly around the pole which is then in its final resting place.

In the event of blast failure or under-estimation of the blasting charge necessary to sink the pole to the required depth, a second or third charge may be placed beneath the pole by repeating the drilling process alongside the pole. Poles as long as 110 feet have been sunk 14 to 16 feet by this method.

Engineering Notes

A Portable Cooler facilitates air conditioning on an eastern railroad. It consists of a baggage truck on which is mounted a blower driven by a $1\frac{3}{4}$ H.P. electric motor. Air is drawn over six blocks of ice, through a screen, and blown into the car through an adjustable louvre which fits an open window in the passageway of a sleeper. Another fan is placed in an open window at the other end of the car to exhaust the air.

This is especially useful for cars which have stood in the hot sun in the yards all day. It saves using the regular air conditioning equipment of the car to remove the heated air, and is applicable to cars which have not the regular equipment.

Specialized Equipment has been resorted to by a number of large concerns for meeting their own individual needs as opposed to having their needs carried out by separate concerns. A large Chicago newspaper recently found that if they supplied their own means of transporting newsprint paper from the paper factory in Canada to Chicago, they could cut down tremendously on their transportation costs.

A Diesel-powered motorship was built for them in England and was put into operation on the Great Lakes between the paper factory and the newspaper offices in Chicago. At the mill, and at Chicago, four loading and unloading cranes were installed, two at each loading platform. They are of the cantilever type and are self-contained, being electrically driven. This unloading equipment is especially remarkable because of its rapid action, which is about two hundred feet per minute with a working load of four thousand pounds.

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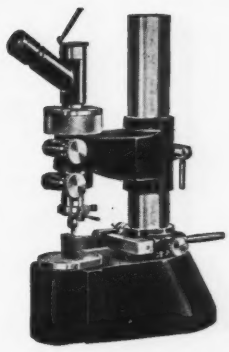

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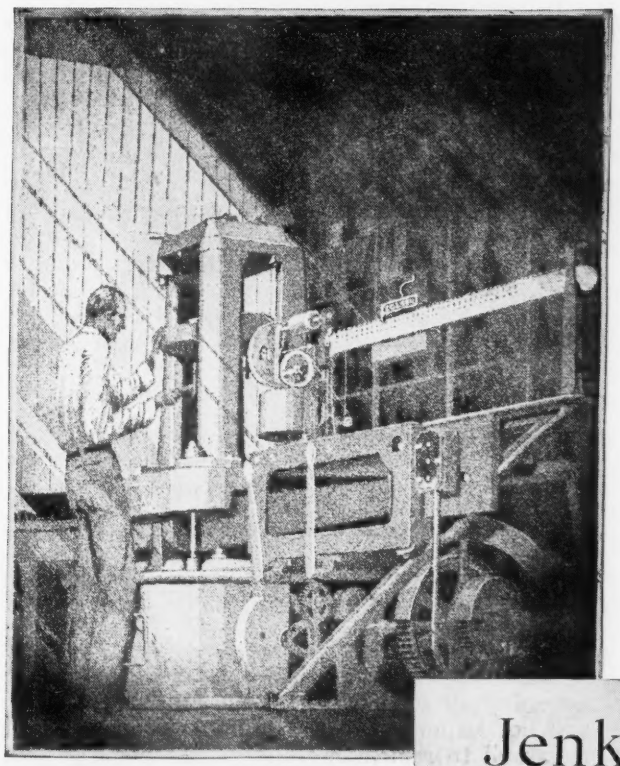

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Engineering Notes

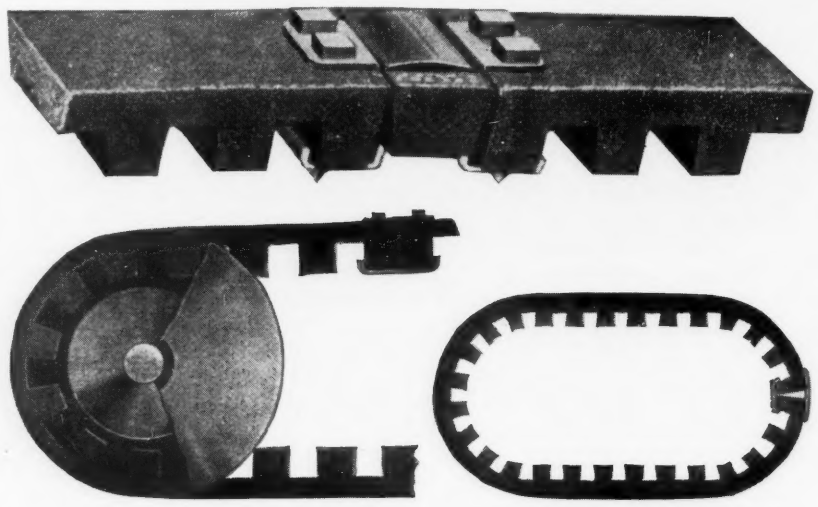
The Link-Wedge Belt is an innovation in the manufacture of belts for power drive. The great fallacy in almost all belts is the liability of considerable friction due to slipping and side play. Because of this, it has always been impossible to use a belt in any kind of timed machine. That is, there is always a maximum risk that the machine, whatever it may be, will become out of synchronism if the belt which operates it slips at any time, for instance during starting and stopping action. In all timed machines, therefore, it has always been necessary to use a chain or gear drive, which is at the best noisy and immobile.

The link-wedge belt is an attempt to overcome these objections. A large rubber company in the United States has taken over the manufacture of this type of belt which is under German patents. The belt resembles a chain in that it has teeth which are integral with the belt proper, all being made of one piece. This belt is used to drive anything for which a maximum amount of traction is required, the teeth fitting tightly intospecially prepared gears for the purpose. It is obvious that such a belt, having all the properties of an ideal belt, and at the same time utilizing the principle of the chain, will be a very excellent addition to the necessities of the manufacturing world.

Airplane Propellor Development of recent date has for its objective the construction of a lighter, stronger, and more efficient type of blade than that now in use. Experiments to attain reduction in weight and centrifugal stress are now being made through the employment of lighter alloys and the construction of hollow blades from high strength alloy steel.

Magnesium alloy, because of its low specific gravity (1.80) as compared to that of aluminum (2.80) offers considerable promise in reduction of propeller weights. Like aluminum, however, it is susceptible to corrosion from salt spray but is not greatly affected by alkalies and acid fumes.

Due to the recent trend toward higher engine powers and increased engine speeds, the strength of propellers has become the principle problem of the designer. Attention has been directed toward steel alloys as the possible solution for this problem and experiments using hollow steel blades have brought out many advantages of this type of blade.



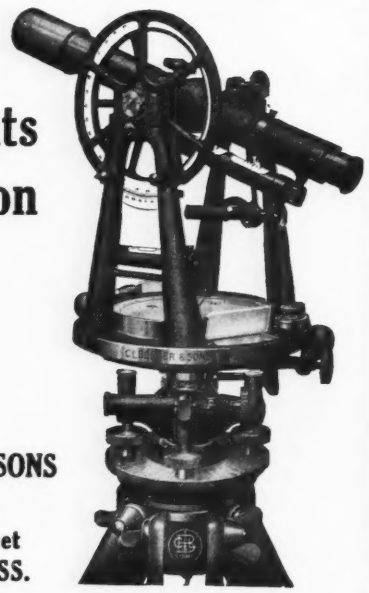
Courtesy Textile World

This belt provides a quiet non-slip drive.

It has been found that by the use of the hollow steel blade new hub designs, much lighter than the present standard types, can be used without loss in strength. In addition, alloy steels have the greatest resistance to pitting and erosion now encountered in seaplane service with aluminum alloy blades, and because of its superiority in torsional rigidity the steel propeller is a smoother running propeller than the aluminum one. The hollow steel propeller also presents the possibility of its use to finally emit gases to the atmosphere through the small openings cut in the trailing edge of the blade from mid radius to the tip. The device has been the most effective muffler tested to date.

The use of hollow steel blades for dirigible power plant installations and large geared engines in which the diameter of the propeller may reach sixteen feet, is a possible solution for the excessive centrifugal and other unit stresses and may result in increased safety and durability and simplicity of design.

Standard Instruments of Precision



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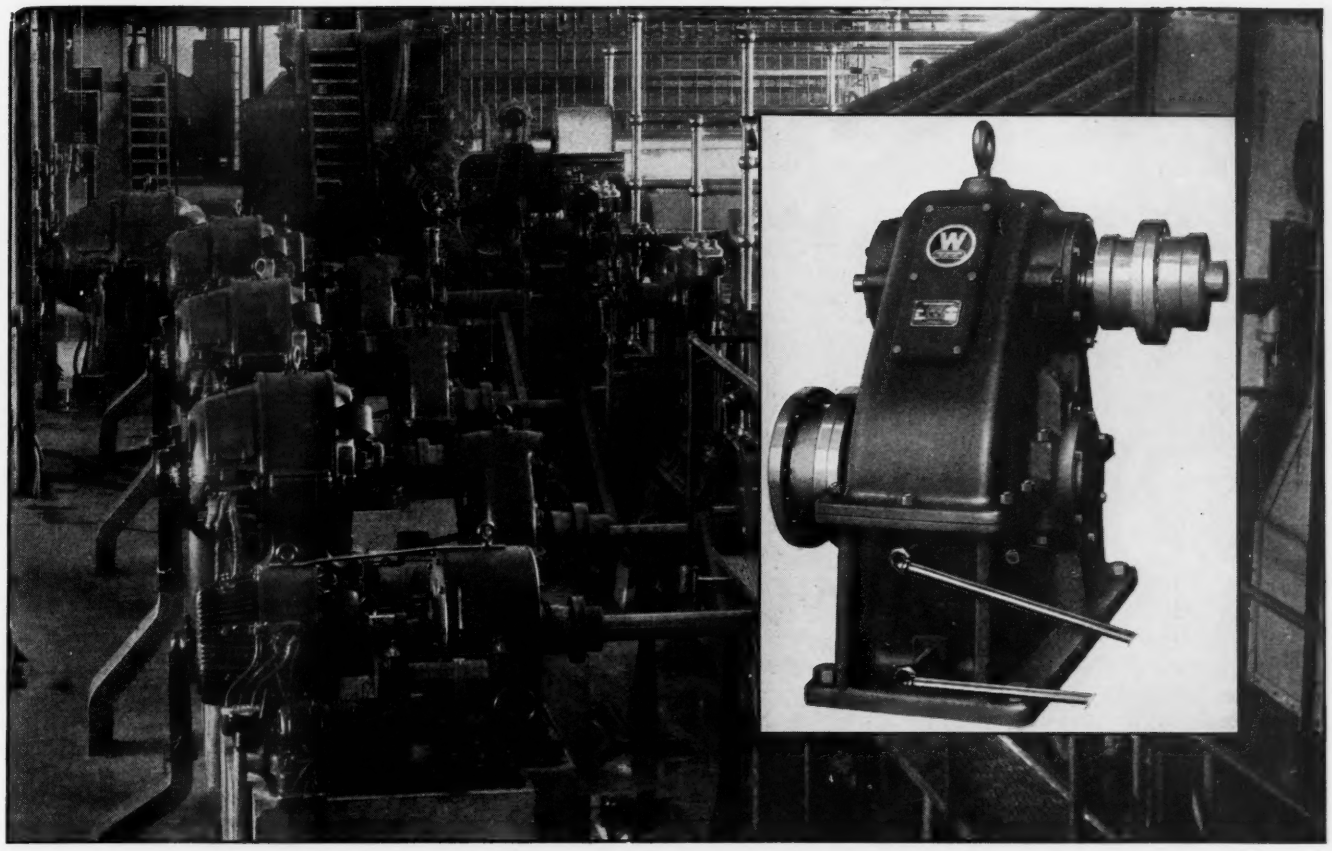
Gear Transmissons

(*Continued from page 295*)

small that no special provision for taking end thrust is needed and it can be made to nearly cancel out anyway by properly arranging the gears.

Perhaps we can develop engines ultimately with torque characteristics which will make gearsets unnecessary, or satisfactory torque changing devices that will not require gear-changing. Until then, however, it is well to remember that modern gearsets are not incapable of improvement. On the other hand their chief virtue is their simplicity and low cost. It may pay to sacrifice a part of this virtue for other advantages, but before doing so, the engineer ought to make sure that the gain more than offsets any losses involved.



These Timken Bearings Have Run 70 Times the Life of the Average Automobile

The pinion bearings in the 6 Westinghouse-Nuttall gear reduction units at the Washington Pulp and Paper Company have each rolled up the enormous total of over 2,338,000,000 revolutions, and a recent check-up shows that they are good for many millions more.

Loaded 100% of their Timken catalogue rating, they have averaged 6¼ days per week, 24 hours a day since they were installed in April, 1923.

The total distance traveled by each of these bearings is the equivalent of driving an automobile more than 3,500,000 miles, whereas the average automobile travels but 50,000 miles during its entire life.

A worthy tribute to Timken stamina! Won't you want this same unequalled endurance in the machinery you design, recommend or buy? The Timken Roller Bearing Company, Canton, Ohio.

TIMKEN *Tapered Roller* **BEARINGS**

Departmental Notes

(*Continued from page 308*)

been very popular. This branch of engineering is of great importance, and Institute graduates hold many high positions in the profession. The Department maintains various field stations for the practical application of its training in the industrial world, and a comprehensive laboratory of applied chemistry.

The Department of Fuel and Gas Engineering, which was organized several years ago in recognition of the growing need for new knowledge in the utilization of our fuels and in other industrial processes allied to the use of fuels, has made some important contributions during the past year. The work of this Department on industrial furnace design was reported at the Second World Power Conference, and the Department has aroused wide interest in the gas and fuel industries.

The need for larger quarters for the Department of Biology and Public Health is indicated by its consistent growth. The Department has done in the field of food technology important work which will be of great value to industry and public welfare.

The course in meteorology, established two years ago, shows great promise, and already the work of the staff has produced important results, for a knowledge of storms and air currents and their underlying causes is absolutely necessary to the safety of aerial navigation.

The growing demand for executives who have had business training with an engineering background resulted in the establishment of the course in engineering administration as a Department of Business and Engineering Administration. As such, it is now separated from the Department of Economics, which continues in its present status.

The Departments of German and of Romance Languages were combined under one head during the year. Interest in German, French, Spanish, and Italian continues to increase with the growing realization among engineers of the importance of being able to read the technical literature of the day, and the growing international character of the relationships between scientific and engineering workers in all parts of the world.

Wide public interest has been shown in the series of popular science experimental lectures which have been given at Technology for many years under the auspices of the Society of Arts. These lectures are given for preparatory school students and for the general public during the winter, and the eagerness with which they are awaited is a strong indication that the layman has a keen interest in scientific and engineering knowledge presented in terms of common understanding.

Oceanographic Institute

(*Continued from page 297*)

are formed and the temperature of the surface water, by securing cores of the mud and studying the stratifications, it can be shown whether or not there have been in the past widespread changes in depth. At the same time we may learn something about past variations in the climate of the earth. For these reasons the new vessel will be equipped with heavy sounding tubes and

(*Continued on page 321*)

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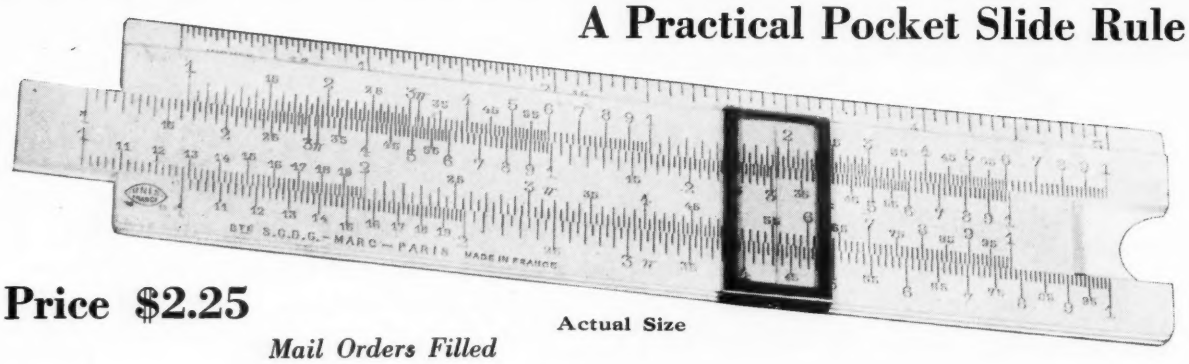

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Oceanographic Institute

(*Continued from page 320*)

dredges for the collection of bottom samples from even the deepest regions of the ocean.

Such studies come under the heading of Physical Oceanography, but there is in addition the whole field of Marine Biology which will also be under the scope of this new undertaking. This phase of the ocean has been more fully investigated than the physical problems, because there already exist several well-founded marine laboratories. Unfortunately, few of them possess an ocean-going vessel and their investigations cannot be extended far out to sea. Therefore, it is probable that the new Institution at Woods Hole will stress the biological problems of the deep water. Studies will be made in the distribution of the various chemicals in sea water which affect its productivity. Extensive collections will be made of deep sea animals in such a way as to learn not only their lateral, but also their vertical distribution. For such work the research vessel can easily be converted into an efficient deep sea trawler and her extremely long wire cable will allow nets to be towed at all depths.

The reader can now see that a good oceanographer should be both a seaman and a scientist. In much of the work which needs to be done at sea, a knowledge of engineering is also important as special instruments have to be developed that can withstand hard usage on shipboard and the corrosive effects of salt water. It is obvious that Tech men can be of great assistance to this undertaking and it is hoped that many of them will take an active part.

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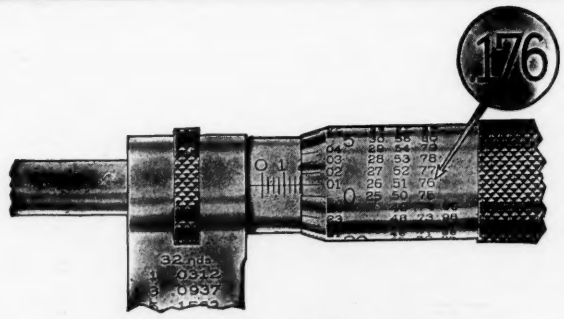

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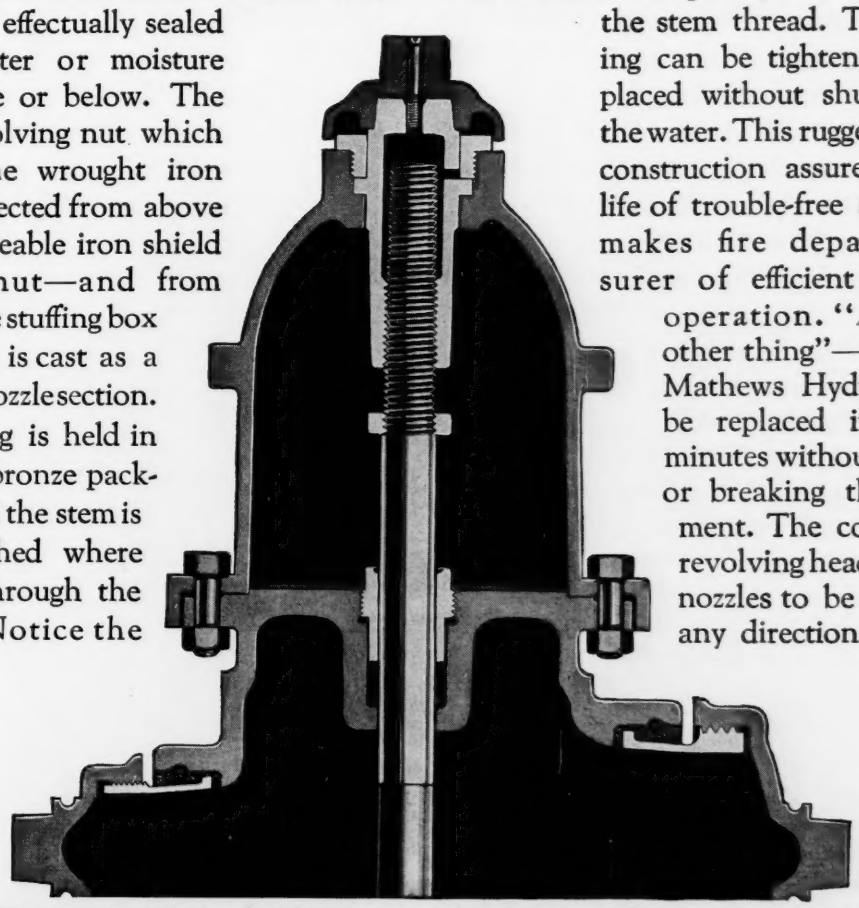

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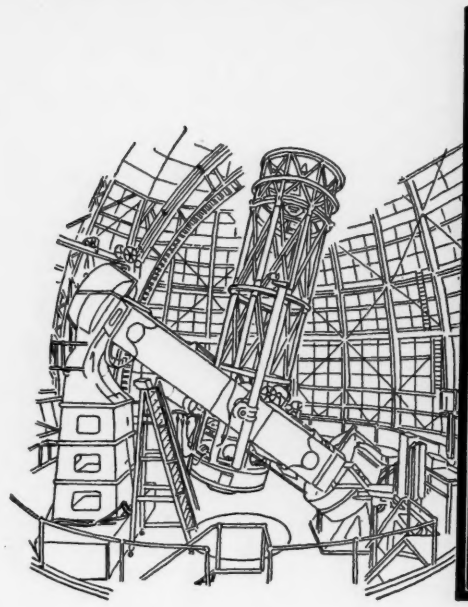

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